**Greening Affordable Housing:**
**An Assessment of Housing under the Community Development Block Grant and HOME Investment Partnership Programs**

**By**

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**Abstract**

Affordable housing programs constitute a significant expense for many local Community Development Block Grant and HOME Investment Partnership program local government recipients. According to literature, it is sound public policy to use Green building methods in affordable housing programs. The research develops a model affordable Green building program to assess Texas local government Community Development Block Grant and HOME Investment Partnership recipients' housing construction programs using administrators' perceptions. Following the assessment, the research provides recommendations for improving Green building practice under those programs. The simple, straightforward model is designed for administrators lacking technical expertise in Green building. The model developed could be used as a template for Federal Green building standards under the two programs.

Data collected from a Web-based survey of local government program administrators is used. The administrators were asked specific questions about their housing construction programs. Survey results are compared to the model affordable Green building program in order to assess how well local government programs have implemented Green building practices in their affordable housing programs.

The data reveals local government programs do not align with the model affordable Green building program. Even so, data reveals the programs are capable of meeting the model requirements given that on most survey responses, a few administrators indicated they followed a particular standard at least most of the time. By following recommendations presented, local government recipients can bring their affordable housing programs closer to the model.

## About the Author

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# Chapter 1: Introduction

Affordable housing is about more than affordability and housing. Affordable housing shapes the lives of its residents, alters the dynamics of neighborhoods, and affects the environment in many ways (Global Green 2006, 17).

Green design is experiencing a renaissance as new concerns over the long-term viability of current energy sources rises and awareness of human activity's impact on Earth's ability to sustain life continues to grow (Rather 2006, 1). To date, most efforts in the field of resource-efficient design have focused primarily on commercial building. Until the last two to three years, little effort has been devoted to "greening" traditional affordable housing (Global Green 2006, vii). Typically, developers (public or private) construct affordable housing on a tight margin, using nominal building codes as a guideline. Due to a combination of rising energy prices, advancements in Green technologies and techniques, and the availability of new funding streams, affordable housing organizations like Community Development Corporations (CDC) have begun placing emphasis on the creation of housing that is environmentally friendly (Rather 2006).

Significant inroads have been made into the application of technologies that improve the performance characteristics of building components and the energy efficiency of the building envelope. These building technologies, however, have only received widespread adoption within the upper-income housing market. The United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design (LEED) program, the most commonly referenced Green building guideline nationally, does not address affordable housing needs adequately. By USGBC's own admission, LEED "actively promotes the transformation of the mainstream home building industry towards more sustainable practices. LEED targets the top 25 percent of new homes with best practice environmental features" (USGBC 2007, 4). In addition, LEED was designed to assess and label newly constructed homes. It cannot be used to assess or label a portion of a home. Only substantial or "gut" rehabilitation projects may be included in LEED at this time. Partially renovated homes cannot be rated under LEED (USGBC 2007, 6). There is no set of standards tailored to the needs of Green affordable housing, though Enterprise Community Partners, Inc. does have a "Green Communities" checklist used to evaluate applicants for funding (ECP 2007, 2).

Equitable development should not just be about justice and fairness; it should also enable the poor to make choices themselves, and create the potential for improving the quality of life while not jeopardizing the opportunities of others to do so (Chiu 2004, 73). Virtually no widespread Green building adoption has occurred within the low-income housing market. This is due to the perceived high cost of material inputs, barriers to financial feasibility, lack of knowledge within this sector of the industry, or institutionalized resistance to change (Phillips 2006, 9). Government no doubt plays an important role in shaping green values, attitudes and norms in housing production and consumption. Legislation, regulations and codes are reflections of social and cultural values and are norms of a society, but they require efforts and commitments from the governments to formulate and enforce them (Chiu 2004, 71). Several cities have adopted Green building programs, many of which emulate the program begun by Austin, Texas (Rather 2006, 6).

Green affordable housing is better designed and built, more durable, not significantly more expensive, cheaper to operate, healthier, more environmentally sound, and less risky[1]. Mississippi, following Hurricane Katrina, found building high-quality, durable, healthy, energy

[1] See Connelly 2006; and USGBC 2007, 4 for additional explanation.

efficient low income housing for low income families was sound public policy[2]. Beyond environmental and quality of life issues, Green building can reduce reliance on imported fossil fuels through conservation and reuse.

Housing under the Community Development Block Grant and HOME programs should build green because the construction and operation of conventional buildings have numerous detrimental effects on the environment, public health, and the economic stability of low-income communities[3]. Housing should be safe, affordable, and healthy; it is a public asset and requires wise investments. At this time, there is no model Green building program tailored to the needs of affordable housing, particularly federally assisted affordable housing.

## Research Purpose

The research develops a model affordable Green building program to assess Texas local government Community Development Block Grant and HOME Investment Partnership recipients' housing construction programs using administrators' perceptions. Following the assessment, the research provides recommendations for improving Green building practice under those programs.

To housing advocates and those who seek affordable shelter in suburban communities, saving the local environment may serve as code for exclusionary zoning and all it conceals. To those who seek to protect the environment, an aggressive affordable housing policy may be

[2] See Phillips 2006, 12; Connelly 2006; USGBC 2007, 156 for explanation of the economic and societal costs associated with escalating energy costs and the positive private and social benefits that homeownership and high quality building creates.

[3] See Wells 2006; and USGBC 2007, 4 for general discussion of the detrimental effects conventional construction has on the environment, public health, and the economic stability of low-income communities. So often federally assisted housing programs seek to provide improvements in the cheapest manner possible with little regard for their lasting effects. As cheap improvements quickly deteriorate, the neighborhood never escapes the blight. Similarly, disregard of site selection can provide affordable housing, but place low income individuals in a location with low access to jobs and essential services.

received as the lumbering intervention of a distant and ill-informed regulatory state (Russell 2003, 440). However, the convergence of Green building methods with Federal affordable housing development represents a great opportunity to produce housing that is economical and ecologically friendly (Rather 2006, 99; USGBC 2007, 156).

Developing a Green building program ideal model for the Community Development Block Grant (CDBG) and HOME programs should contribute significantly to increases in Green building. The amount of money available to CDBG and HOME programs for housing construction is usually restricted, often well below the housing market[4]. Builders can construct a better quality home by incorporating resource efficient building practices without increasing first costs yet decreasing life cycle costs for the homeowner, resident and operator. In building green, the potential for enhanced marketing, savings, and environmental protection is ultimately increased [5]. Demonstrating Green building practices in a financially restricted setting, such as the CDBG and HOME programs, shows private sector housing developers their perceptions of increased costs are inaccurate. In addition, it reduces or eliminates many of the cost-related arguments against local government Green building requirements.

The model developed through this research could serve as a template for a Federal Green building standard for housing activities. Also, the research provides a valuable resource for public administrators to gain Green building knowledge, which increases the likelihood of Green program adoption.

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[4] For example, the City of San Marcos, Texas HOME program cannot spend any more than $60,000 on any individual housing unit. In 2007, the average home sales price in San Marcos was $145,000, while the average home tax value was $106,962.
[5] See Global Green 2006, vii; Chiu 2004, 70; Connelly 2006; and Magnelli and Sloss 2006 for additional information on costs and benefits of Green building.

**Chapter Summaries**

To achieve the research purpose, this study is divided into six chapters. Chapter 2 provides an overview of the history and institutions involved in the Green building movement, discussion of the CDBG and HOME programs, federal efforts to promote Green building, and special cost considerations for Green building in affordable housing. With the setting established, Chapter 3 develops a model Green building program for affordable housing using supportive literature. The research methodology, including a discussion of the survey instrument, the unit of analysis, sample population, and respondents follows in Chapter 4. Chapter 5 applies the methodology with a discussion of the survey results and data analysis. The final chapter, Chapter 6, is a summary of the research findings in relation to the overall purpose of the study. Implications and recommendations for future research are also developed.

## Chapter 2: History and Institutional Setting

The purpose of this chapter is to provide information about the history of Green building, Green building and Federal government institutions applicable to this study. In addition, it considers costs in Green building given the affordable housing context of this study, and existing Federal efforts to promote Green building.

### History of Green Building

Although "Green" was not used until fairly recently, there is a long history of efforts to design enclosed habitats for human use compatible with the natural environment. In some cases, this was done because the local resources available demanded it. For example, in 11$^{th}$ century Iceland, a scarce supply of construction materials forced the inhabitants to construct the roofs of their homes using a layer of sod—much like the "Greenroofs" covering many contemporary buildings for the purpose of reducing urban heat island effect and mitigating the effects of stormwater runoff (Velazquez 2005). Light-harvesting techniques have been used since the time of the Pharaohs to bring the light of day into a dwelling, often using skylights. The ancient Egyptians constructed shafts hundreds of feet in length within their pyramids. Strikingly similar to today's solar tubes, Egyptians used mirrors to reflect the captured light into interior dark spaces long before the invention of the light bulb (Rather 2006, 6).

Sustainable architecture grew initially as a reaction to a situation created by the massive construction boom in the US following the Second World War (Rather 2006, 6). The root of the green building movement in its present form has its genesis in the fuel crisis of the 1970s. This era included mass migration of the middle class from cities to newly created suburbs, driven in large part by the availability and convenience of the automobile, racial concerns, and eased financial accessibility. The US government sponsored entities (GSEs), commonly known as Fannie Mae and Freddie Mac, set a trend that led most other financial institutions to facilitate low-interest home loans to those wishing to settle down with families in suburbia (Rather 2006, 6).

Thirty years later, the energy crisis of 1973 demonstrated the suburban pattern of development was heavily dependent on access to inexpensive oil. The once reviled urban cores received more attention than they had experienced in decades. The increased oil prices caused monthly utility costs to increase rapidly, clarifying the need for a new paradigm in construction based upon the responsible use of energy resources (Jones 1998, 755). This initiative lost momentum once fuel prices returned to low levels, but has since regained popularity in light of concerns over global warming, rising fuel costs and anxiety about energy independence. With this renewed interest came development of new institutions and programs targeting Green building.

**Green Building Institutions**

Rebecca Chiu (2004, 65) maintains sustainable housing development is “housing development that meets the housing needs and demands of the present without compromising the ability of future generations to meet their needs and demands.” Green building is an essential way to move housing development in a more sustainable direction. Green building uses materials and methods promoting environmental quality, economic strength and social/cultural improvements through design and development of the built environment, and its continuing maintenance and operations (ECP 2007, 3).

Many researchers, communities, and organizations have been experimenting with developing a working list of sustainability indicators and Green building characteristics. One of the best known is Wackernagel and Rees's "Ecological Footprint" concept (Rees & Wackernagel 1996). Unfortunately, the indicators used in their work are not specific enough to housing for the purposes of this research.

In general, Green building standards can be split into programs created by and/or for municipalities, and those driven by advisory organizations. A number of cities and towns across the United States have developed Green principles tailored to their own needs. Examples of strong municipal Green building programs include Portland, OR, San Francisco, CA, and Austin, TX. Advisory organization-driven guidelines for high performance buildings include Energy Star, the National Association of Home Builders' Green Home Building Guidelines, and Leadership in Energy and Environmental Design (LEED). As of mid 2007, no universal Green building standard exists. Creation of a universal standard is difficult because factors such as climate, the needs of the building occupants/users, building size and function, and the amount of resources available toward building a particular project Green all can vary widely (USGBC 2007, 3). For example, a Green building constructed in Arizona will likely be considerably different from one built in Massachusetts, as the primary concern when building in Arizona is keeping occupants cool. In New England, the cold climate dictates heating a building effectively is of greater importance than optimizing cooling ability.

Energy Star[6], while too limited in scope to be considered "Green", represents a compromise between true Green standards and the standard building code. It was created via a

[6] To qualify as an Energy Star house, a builder sends house plan, application and $75 fee to Energy Star's main office. Inspections are conducted twice: once after insulation and again after drywall and HVAC are in place. A final inspection is conducted when all systems are operational. In addition, individual electronic appliances are certified as Energy Star if they meet particular efficiency requirements, typically at least 15 percent more efficient than the Federal manufacturing standard. On the Internet, visit http://www.energystar.gov for additional information.

partnership between the United States Environmental Protection Agency and the Department of Energy in 1992 (Phillips 2006, 3). To meet Energy Star standards, a building must make use of such technologies as energy-efficient Low-E windows, High-R value insulation, sealed ductwork, high-efficiency appliances, and a tight building envelope to reduce the effects heating and cooling losses caused by infiltration. Energy Star compliance is a frequent performance measurement for housing programs funded through Housing and Urban Development federal grants.

The set of standards for Green building put in place by the National Association of Home Builders (NAHB) represent a step up from Energy Star. The *NAHB Model Green Home Building Guidelines*[7] consider lot design, resource efficiency, energy efficiency, water efficiency, indoor environmental quality, operations and maintenance, and global impact. The focus within this manual is on single-family home construction, as that is the NAHB's organizational province (NAHB 2006).

The United States Green Building Council's (USGBC) Leadership in Energy and Environmental Design program (LEED)[8], is the most widely used standard in Green construction. The USGBC is a not-for-profit organization that advocates for sustainable building design, and is one of the seven original national Green building councils that helped to found the World Green Building Council in 1999. The USGBC recognizes that it is impossible to create a uniform Green building code, and has thus created a number of standards. LEED considers innovation and design process, location and linkages, sustainable sites, water efficiency, energy

[7] On the Internet, see http://www.nahb.org/fileUpload_details.aspx?contentTypeID=7&contentID=1994 for the full guidelines.

[8] LEED certification provides independent, third-party verification that a building project meets the highest performance standards. The LEED plaque is recognized nationwide as proof that a building is environmentally responsible, profitable, and a healthy place to live and work. LEED uses a checklist, with some mandatory and some optional criteria, with each checklist item assigned a point weight. Based on the number of points earned, a project earns one of four graduated certification levels. See http://www.usgbc.org/DisplayPage.aspx?CMSPageID=147 on the Internet for the full guidelines.

and atmosphere, materials and resources, indoor environmental quality, and awareness and education (USGBC 2007, 3). LEED is often used as a basis for Green building design, but LEED Certification is often not sought because there are no clear, tangible benefits to being LEED certified. Rather's (2006, 66) findings indicate LEED makes a better guideline than a certification for affordable housing at this point.

As discussed earlier[9], LEED does not address affordable housing needs adequately. The Initiative for Affordable Housing is a component that addresses the inherent differences between affordable housing and market rate, single-family homes. Its ultimate goal is to "recognize and reward the intrinsic resource efficiencies of affordable housing for the LEED for Homes rating system" (USGBC 2007, 155). The component, however, still falls short as many of its remaining criteria remain financially unattainable or require extensive technical experience. The USGBC believes this encourages the development of housing based on the three facets of sustainability: economics, equity and environmental responsibility. It includes several measures specifically intended to reward efficiencies typical of affordable projects: compact development, promoting infill, limiting outdoor water use, access to community resources, and houses smaller than the national average. Collectively, these represent more than 50 percent of the points needed to achieve a certified LEED Home (USGBC 2007, 155).

In addition, LEED for Homes was designed to assess and label newly constructed homes. It cannot be used to assess or label a portion of a home. Only substantial or "gut" rehabilitation projects may be included in LEED for Homes at this time. Partially renovated homes cannot be rated under LEED for Homes (USGBC 2007, 6).

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[9] See page 7.

Green Communities[10] is the first national green building program focused exclusively on affordable housing. It offers grants, loans, tax-credit equity, training and technical assistance using its *Green Communities Checklist* as an evaluative criteria (ECP 2007 (2)). While Green Communities provides a Green building program designed for affordable housing, it is not designed to operate in the financially restricted setting of CDBG and HOME housing programs. Likewise, the technical nature of the checklist is incompatible with the needs of program administrators.

**Overview of the HOME and Community Development Block Grant Programs**

To understand the selection of attributes for the Green building model, one must consider the housing programs' institutional context. The housing evaluated in this research is constructed as part of the HOME Investment Partnership (HOME) and Community Development Block Grant (CDBG) Programs.

Title II of the Cranston-Gonzalez National Affordable Housing Act authorizes the HOME Investment Partnership Program (USHUD 2007 (2)). HOME is the largest Federal block grant designed exclusively to create low-income affordable housing (USHUD 2007 (2)). The program purpose is to provide decent, safe, sanitary and affordable living environments (USHUD 2007 (2)). It was created because the supply of affordable housing is diminishing, living environments have deteriorated, reliable Federal leadership is needed, and to protect the investment in low-income housing to guarantee affordability for the life of the property (USHUD 2007 (2)).

[10] On the Internet, see http://www.greencommunitiesonline.org for full description of Green Communities' programs and Green building checklists.

The Department of Housing and Urban Development awards HOME funds annually as formula grants to participating jurisdictions. Participating jurisdictions can use the funds as grants, direct loans, loan guarantees or other forms of credit enhancement, or rental assistance or security deposits (USHUD 2007 (2)). Local jurisdictions become eligible when they qualify under the need-based formula for $500,000 (USHUD 2007 (2)). The jurisdictions often use the grant to assist with home purchasing or rehabilitation financing, building or rehabilitating homes, or other expenses related to the development of non-luxury housing (USHUD 2007 (2)). HOME requires jurisdictions provide 25 percent leverage from non-federal sources and 15 percent of the grant be distributed to Community Housing Development Organizations. Assistance from the grant requires restrictions to maintain affordability for 5-20 years, depending on circumstances (USHUD 2007 (2)). There are 579 local government recipients nationally, of which 42 are located in Texas[11].

The purpose of the Community Development Block Grant (CDBG) is to develop viable urban communities by providing decent housing and a suitable living environment, and by expanding economic opportunities, principally for low- and moderate- income persons. The program is authorized under Title 1 of the Housing and Community Development Act of 1974. Recipients must give priority to activities benefiting low- and moderate-income individuals, preventing slums and blight, and/or meeting particular urgency. Eligible grantees are principal cities of Metropolitan Statistical Areas, other metropolitan cities with population greater than 50,000, and qualified urban counties with populations greater than 200,000 excluding the population of entitlement cities. Eligible activities include rehabilitation of residential and non-residential structures and activities related to energy conservation and renewable energy sources.

[11] San Marcos, Texas, the author's employer received HOME funds as a subrecipient to the State of Texas; it does not qualify as a HOME Participating Jurisdiction as of Summer 2007.

Entitlement jurisdictions cannot use the funds to construct new housing by units of local government (USHUD 2007 (1)). There are 1,108 local government recipients nationally, of which 75 are located in Texas[12].

**Promoting Green Building in the Department of Housing and Urban Development**

The Federal government has enacted multiple regulations, legislative initiatives and agency programs to encourage energy efficiency in housing in an effort to reduce the negative economic impact of high energy costs and the related depletion of natural resources (Phillips 2006, 3). **Table 2.1** highlights some of the key policies as they relate to affordable Green building.

**Table 2.1: Summary of Federal Green Building Policies**

| Program | Key Issues |
|---|---|
| Section 945 of the 1990 Affordable Housing Act | ▪ Encourages adoption of the model energy code for new construction<br>▪ Advances a partnership between the Department of Energy (DOE) and Department of Housing and Urban Development (HUD)<br>▪ Gives direction to reduce utility costs in public housing<br>▪ Emphasizes energy efficiency in HOPE VI programs<br>▪ Expands the use of energy-efficient mortgages<br>▪ Improves financing for energy improvements in manufactured housing<br>▪ Increases emphasis on sustainable development |
| Energy Policy Act of 1992 | ▪ amended Section 109 of the 1990 Affordable Housing Act<br>▪ All new construction assisted by HUD must meet energy efficiency standards, including all HOME programs |

[12] San Marcos, Texas, the author's employer, is a CDBG entitlement jurisdiction.

| | |
|---|---|
| Partnership for Advancing Technology in Housing (PATH) | ▪ Dedicated to improving the quality, durability, environmental efficiency, and affordability of homes through the use of technology<br>▪ Supported by Department of Housing and Urban Development, Department of Energy, Department of Commerce, Department of Agriculture, Environmental Protection Agency, and the Federal Emergency Management Agency |
| State Energy Program of 1996 | ▪ strengthens States' capabilities to promote and adopt energy efficiency and renewable energy technologies<br>▪ Supported by Department of Housing and Urban Development, Department of Energy, Department of Commerce, Department of Agriculture, Environmental Protection Agency, and the Federal Emergency Management Agency |
| Federal Housing Administration Energy-Efficient Mortgages | ▪ became a congressionally mandated national program in 1995<br>▪ In recognition that reduced utility expenses permit homeowners to pay a higher mortgage |
| Building America | ▪ A private-public partnership designed to combine the knowledge and resources of industry leaders with the Department of Energy technical capabilities to promote environmental improvements in home building<br>▪ emphasizes a systems engineering approach to produce housing that incorporates energy and material saving strategies throughout the design and building process |

(Phillips 2006, 3)

However, given the financial constraints of federally assisted affordable housing, builders must carefully consider the costs of Green building more than they would if constructing housing as a market-rate or non-profit developer.

**Costs of Going Green**

Any usable model for Green building in the affordable housing context must consider costs and financial feasibility of Green building strategies. Housing developers commonly associate "Green building" and "environmental stewardship" with higher costs and delays. Building green does not always cost more. One can build a better quality home by incorporating resource efficient building practices without increasing first costs yet decreasing life cycle costs for the homeowner, resident and operator (Global Green 2006, vii). In building green, the potential for enhanced marketing, savings, and environmental protection is ultimately increased (Global Green 2006, vii). For instance, Rebecca Chiu (2004, 70) found consumers tend to support environmental design practices that support thrift, rather than environmental stewardship exclusively.

As such, there exists some limited information regarding the costs of Green development over conventional development, often referred to as a "Green Premium". Edward Connelly (2006) found the typical green premium for an affordable Green-built house was 2.94 percent of total development costs (hard & soft costs). He found the median cost of greening as a percent of total construction costs without present value is 3.83 percent. The premium buys financial benefits, including reduced costs and increased project value over 30 year life-cycle and many non-quantifiable benefits (Connelly 2006).

Similarly, Arroyo Chico in Santa Fe, NM was able to construct single-family detached homes, targeting low income, at an incremental cost to build green of only 0.90 percent, or $1,017 per unit. They were able to include passive solar design, xeriscaping, low-e windows, ceramic tile flooring, water harvesting systems, cellulose blown insulation, radiant floor heating, and a metal roof. The net present value to residents was $7,820 per unit, or 5.08 percent (Connelly 2006). Likewise, Magnelli and Sloss (2006) found the Green premium on affordable housing to be $2,495[13].

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[13] This is consistent with construction bids in the City of San Marcos, Texas HOME Owner Occupied Assistance program for FY2005, which will be constructed Summer 2007. The primary Green building bid alternate for each house reconstruction was $2,000. However, the lack of developers familiar with many of the Green building bid alternates did cause higher bids on many alternates. In the case of one bidder, the bid for an Energy Star constructed house was $12,000. The consensus among bid reviewers was that particular builder was unfamiliar with Energy Star construction and did not wish to participate if houses were built using those methods.

Despite a Federal record of promoting aspects of Green building, availability of Green building institutions, and cost feasibility, an affordable Green building model is conspicuously absent. Chapter 3 seeks to remedy this gap through development of a Green building model for affordable housing.

## Chapter 3: The Model Affordable Green Building Program

The purpose of this chapter is to review the literature on affordable housing and Green building practice to develop model components for Green practices in housing construction, reconstruction and rehabilitation under the Community Development Block Grant (CDBG) and HOME Investment Partnership (HOME) programs. The model is then used to assess CDBG and HOME funded housing activities of entitlement jurisdictions and participating jurisdictions. The essential components include:

- Energy systems;
- Water conservation;
- Indoor air quality;
- Site selection, site design and landscape ecology;
- Building ecology, waste and recycling;
- Integrated design; and
- Owner and occupant education

Creating synergy between Green building and affordable housing development under the CDBG and HOME programs represents a unique challenge. The two programs have limited financial resources, and, in the case of CDBG, have many other eligible functions pulling interest away from housing. In addition, many of the professionals administering these grants have little detailed knowledge of Green practices in housing development. Any Green building requirement should be developed to allow these professionals to implement the program easily. Beyond program standards, attempting to green a rehab unit is a different challenge from a new green unit, but the difficulty is not necessarily worse than new construction. In fact, rehabilitation may produce results that are nearly as effective and efficient as new construction (LaRue 2006).

Green affordable housing is better designed and built, more durable, not significantly more expensive, cheaper to operate, healthier, more environmentally sound, and less risky (Connelly 2006; USGBC 2007, 4). Housing under the CDBG and HOME programs should build green because the construction and operation of conventional buildings have numerous detrimental effects on the environment, public health, and the economic stability of low-income communities (Wells 2006; USGBC 2007, 4). Green housing improves affordability and durability, improves performance, creates smaller environmental footprints, and improves occupant health (Connelly 2006) (USGBC 2007, 4). Through energy-efficiency, it can assist in reducing reliance on fossil fuel imports. Connelly (2006) argues Green affordable housing can provide a better sense of community and pride of owning or living in a superior asset, helping to break cycles of generational poverty.

**Energy Systems**

The first component of the model Green building program is energy systems, which includes whole house energy efficiency certification; energy efficient lighting, fixtures and appliances; energy efficient heating, ventilation and air conditioning systems (HVAC); tight construction; and passive solar design.

Energy consumption has many environmental impacts, from mining of fossil fuels to emissions from burning them. The environmental impacts of home energy consumption accrue over time, warranting heavy consideration in any Green building strategy (NAHB 2006, 2). Energy conservation mitigates the cumulative burdens of energy production and delivery, extraction, degradation of air quality, global warming and increasing pollutant concentrations (ECP 2007, 6). Housing is responsible for 22 to 40 percent of annual American energy use and

30 percent of American carbon dioxide production, leading to global warming and air pollution (Wells 2006; USGBC 2007, 4).

Despite environmental benefits, the prime motivator for the government's emphasis on energy-efficient affordable housing has been to provide tenants with high quality housing and reduced utility costs (Rather 2006, 16). Energy costs are often a large shelter expense, second only to mortgage payments/rent (Doxley 2006). Housing is the single largest expenditure in the budgets of most families and individuals. The average family puts 25 percent towards it, while the poor and nearly poor put half (Quigley 2004). Energy dollar savings help low-income families relatively more than their middle class counterparts (Wells 2006).

Currently, an inverse relationship exists between household income and residential energy consumption and residential energy expenditures. Lower income groups consume and expend more per square foot for residential energy than do higher income groups in the US (Phillips 2006, 5). A Federal government study found the US median income household spends four percent on utilities, while Social Security Income (elderly) households use 19 percent and Aid for Families with Dependent Children[14] recipients use 26 percent (USHUD 2007 (3)). A National Low-Income Energy Consortium (NLIEC) study found average annual percentage of income spent on home energy costs was 4.6 percent for median income households, while low-income averaged 19.5 percent. NLIEC also found the average income spent on home energy costs can reach 70 percent of monthly income for low-income families and seniors on fixed incomes. Low-income households saw their energy cost burden increase 36 percent from 2000 to 2001, substantially more than their middle and upper class counterparts (NLIEC 2003, 3).

[14] American Families with Dependent Children (AFDC) was reformed in 1997 and replaced with Temporary Assistance for Needy Families (TANF). However, many still refer to it by its historic name, including many HUD documents.

Although the concept of affordability includes rent and utilities, the burden of utility costs is frequently not a priority consideration during the construction of housing for low-income homeowners. Likewise, little consideration is given to the disproportionate burden that utility costs impose on low-income homeowners and how those costs impact the ability of the low-income homeowner to meet mortgage payment obligations. Phillips (2006, 7) found in most low-income housing, quality and energy efficiency are compromised to reduce construction costs.

High energy costs have significant negative impacts on low-income families. Several studies have demonstrated a strong negative relationship between ability to pay its home energy bills and consequences such as homelessness, malnutrition, heart disease, heat stroke, and disintegration of families (NLIEC 2003, 3). A 2003 National Energy Assistance Directors Association (NEADA) (2004, A1) study found 17 percent of low-income families were unable to use their main source of heat due to discontinued utility service or inability to pay for fuel, and eight percent had their electricity shut off due to nonpayment. The same study found several problematic impacts of high energy costs:

- 22 percent went without food for at least one day;
- 38 percent went without needed medical and/or dental care;
- 30 percent went without filling a prescription or taking a full dose;
- 21 percent became sick because their home was too cold;
- Seven percent became sick because their home was too hot;
- Five percent of those reporting illness caused by temperature indicated the illness resulted in a doctor or hospital visit;
- 20 percent were not able to pay energy bills due to medical expenses;
- 28 percent did not make a rent or mortgage payment;

- Nine percent moved in with family or friends;
- Four percent were evicted; and
- Four percent became homeless

As many as 3.6 million families in 18 states plus the District of Columbia risk having their energy cut off because of the effects of rapidly increasing energy costs. In St. Paul, Minnesota, 26 percent of evictions were due to electric and gas termination, and 40 percent of evictions were due to water cutoffs (USHUD 2007 (3)).

Although there are multiple Federal and State programs that provide assistance to low-income persons to offset the burden of residential energy costs, failure to address the core problem—energy inefficient low income housing—can only result in continuously escalating financial and societal burden as energy costs continue to increase (Phillips 2006, 5). In addition, many of these programs lack the financial ability to help all of those that qualify. Approximately 4.6 million households received Low Income Home Energy Assistance Program in 2003, only thirteen percent of the over 34.6 million households that were eligible received assistance (NEADA 2004, A2).

Dollars exported out of communities to pay for energy expenditures are a drain on the economic vitality of the community, when these dollars could instead be spent as consumer expenditures or for other economic development purposes within the community (Phillips 2006, 6). Not only are energy costs a drain on local economies, they are also a drain on Federal programs that provide housing and energy supplements for low-income citizens (Phillips 2006, 6). The US Department of Housing and Urban Development spends an estimated $4 billion each year on utilities, approaching 15% of entire budget (Doxley 2006).

For only a five percent initial cost increase, housing developers can make buildings that use 30-50 percent less energy than code buildings to heat and cool, and use 20 percent less electricity overall, reducing energy bills[15] (Connelly 2006; USGBC 2007, 156). Building envelope and energy-using systems most determine a development's environmental impact through their influence on energy use and indoor air quality. Inadequate design makes buildings costlier to build and maintain, makes them uncomfortable, increases maintenance needs, and creates moisture problems. This threatens the health of buildings and occupants alike. First considering the building envelope can allow a building to capture or block energy at almost no cost if properly designed (Global Green 2006, 57). The following sections discuss aspects of efficient energy systems in more detail.

## Whole House Energy-Efficiency Certification

Whole-house energy efficiency certification is essential to creating home energy systems consistent with the model. Buildings use more than one-third of all energy in the United States, and two-thirds of all electricity consumption. Homes and apartments use more than half of the energy used in all buildings in the United States (Doxley 2006). Furthermore, buildings consume or are responsible for 40 percent of the world's total energy use (ECP 2007, 3). In the United States from 1990 to 2001, average energy costs increased $1,600. Improvements that make a home 20 percent more efficient, a conservative estimate for many green homes, could significantly reduce a homeowner's annual utility expenses (NAHB 2006, 2).

One of the best-known whole house energy-efficiency certification programs is Energy Star. Energy Star homes receive independent verification of energy efficiency. Energy Star

[15] Though not the focus of this research, energy efficiency can reduce dependence on foreign fossil fuels through conservation.

homes are evaluated based on heating, cooling, and hot water energy use. The homes typically include building envelope upgrades, high performance windows, controlled air infiltration, upgraded heating and air conditioning systems, tight duct systems and upgraded water-heating equipment. These features improve home quality and comfort, and lower energy demand and reduce air pollution (ECP 2007, 23). James Rather (2006, 61) observes that Energy Star has come to represent a de facto energy code for Community Development Corporations.

Creating an Energy Star qualified house is not prohibitively expensive. **Table 3.1** illustrates the additional costs and credits to building an Energy Star home.

**Table 3.1: Hard Costs and Credits to Building an Energy Star Qualified Home**

| | Additional Cost | Credit (Cost Reduction) |
|---|---:|---:|
| High Performance Windows | $400 | |
| Air Sealing | $150 | |
| Air Barrier Details | $300 | |
| Tight Ducts | $150 | |
| High Performance Insulation | $300 | |
| High-Efficiency Equipment | $400 | |
| Efficient Lighting and Appliances | $300 | |
| Right-sized HVAC | | ($500) |
| Compact Ducts | | ($200) |
| Reduced Framing | | ($200) |
| Furnace Elimination | | ($500) |
| | **Net Cost** | **$600** |

(Doxley 2006)[16]

Energy Efficient Lighting, Fixtures, and Appliances

Seemingly minor portions of a new construction or rehabilitation project represent opportunities to inexpensively improve energy efficiency and should be considered in an affordable Green building model. Appliances account for two-thirds of the electricity used in

[16] See Note 9. In Summer 2007 housing reconstruction bids, San Marcos, Texas found the alternative bid for building an Energy Star Qualified Home was typically $2,000. Based on Doxley's findings, it seems the bidders added the additional costs, but did not consider any of the potential cost reductions resulting from the upgrades.

American homes (USDOE 1999). Energy Star qualified lighting uses two-thirds less energy and lasts six to ten times longer than traditional lighting, resulting in reduced energy use, lower utility costs, and lower greenhouse gas emissions (ECP 2007, 25; NAHB 2006, 110). Compact fluorescent light bulbs (CFLs) use two-thirds less energy than a standard incandescent bulb and must meet additional operating and reliability guidelines (Doxley 2006). Energy Star refrigerators are 15 percent more efficient than the minimum federal efficiency standard (Doxley 2006).

Community Development Corporations frequently use Energy Star appliances, windows and lighting, evidence of the lower cost a perceived value (Rather 2006, 31-55). The Green premium for energy efficient lighting can reach $500, while the premium for appliances is approximately $175 (Magnelli & Sloss 2006). While implementing energy efficiency in appliances is effective, heating, ventilation and air conditioning provides a significant opportunity to reap energy efficiency rewards.

### Energy Efficient Heating, Ventilation and Air Conditioning

Heating, ventilation and air conditioning (HVAC) systems account for a substantial amount of electricity sales to US households and are expected to play a significant role in energy use increases over the next 20 years. HVAC systems accounted for 31 percent of electricity sales to US households in 2001 and the increased use of electricity is projected to account for 68 percent of the projected increase in residential energy use between 2003 and 2025 (Phillips 2006, 4).

Load reducing technology and the systems that supply a building's energy needs contribute to a building's energy efficiency (Stromberg 2005, 17). Several methods are available to improve energy efficiency, many of which are related closely to indoor air quality discussed later in this chapter. Builders may choose to run vents in conditioned space, such as a sealed attic; running them outside can lose 15 to 30 percent of conditioned air (Global Green 2006, 69). Community Development Corporations frequently use high-efficiency HVAC, such as Energy Star, in their projects (Rather 2006, 31-55). The Green premium is not severe considering the potential benefit to occupants, approximately $600 (Magnelli & Sloss 2006). Many methods designed to improve air quality also result in gains to energy efficiency, and reduced heating, ventilation and air conditioning costs. Efficient HVAC often relies on tight construction to achieve maximum performance.

### Tight Construction

Tight construction has a significant bearing on the effectiveness of a home’s energy systems. In commercial and residential buildings, “over 50% of energy loss is associated with heat transfer and air leakage through building envelope components” (Oak Ridge 2007; NAHB 2006, 98). The building envelope should protect structural members from moisture build up, reduce heat leakage, bring in light, and prevent pest problems (Global Green 2006, 59). Good building envelopes can reduce the need for furnaces, air conditioners, and lights, cutting construction and operating costs (Global Green 2006, 59). Community Development Corporations frequently use tight building envelopes in their projects (Rather 2006, 31-55). Penetration sealing typically comes at a $230 premium (Magnelli & Sloss 2006). While tight construction is important, taking advantage of the sun is an often overlooked aspect of efficient energy systems.

Solar Design

To create energy systems in compliance with Green building model, solar design provides a low-cost, yet effective means of improving energy efficiency. Lighting significantly affects energy efficiency and thermal comfort. The sun is an ideal source of lighting that is free and widely available (Stromberg 2005, 19). Daylighting brings outdoor light into buildings, reducing the need for artificial light sources (Global Green 2006, 61). Solar energy is practical, renewable heat energy. The most practical renewable energy use is to heat with solar energy. Community Development Corporations found passive solar design a cost-effective means to improve efficiency and environmental stewardship (Rather 2006, 31-55).

Building orientation is essential for systems to work efficiently. For centuries, people have used roof overhangs, awnings and other techniques to block the sun (Stromberg 2005, 19). Building designers can take several steps to account for solar design (ECP 2007, 14; Stromberg 2005, 20; LaRue 2006; Global Green 2006, 62):

- Elongate building on east-west axis;
- Place interior spaces requiring the most light and heating/cooling along the south face of the building;
- Design a narrow floor plate with single-loaded corridors and an open floor plan to optimize daylight penetration and passive ventilation;
- Design shading through overhangs and canopies on the south and trees on the west prevent the summer sun from entering the interior.

In addition, builders should consider future opportunities for owners to reduce energy use. They should site, design and wire the development to accommodate installation of photovoltaic systems (solar panels) in the future. The initial cost of photovoltaic systems is prohibitive under most programs, but grants and subsidies are available in many states and cities for individual homeowners. Providing connectivity reserves the opportunity to install a system later when the resources become available (ECP 2007, 25).

Like energy efficiency, water conservation makes many strong economic arguments for inclusion in the affordable Green building model, such as utility cost reductions.

**Water Conservation**

Water conservation provides many financial and environmental benefits and warrants inclusion in the Green building model. Water efficiency reduces utility bills while conserving fresh water resources. Between 20 percent and 40 percent of the contiguous United States has experienced moderate to extreme drought in the late 20$^{th}$ and 21$^{st}$ Centuries (ECP 2007, 5). Running a water debt sometimes causes communities to draw on substandard, saline, or polluted sources (Ogorzalek 2003, 27).

While most water consumed in the United States goes to agricultural irrigation, domestic consumption is second on the list. Sixty percent of urban water use is residential, and 24 percent is devoted to toilet flushing alone (Ogorzalek 2003, 25; USGBC 2007, 4). Buildings consume or are responsible for 16 percent to 25 percent of fresh water withdrawal (ECP 2007, 3; Wells 2006).

In 2005, mean per capita indoor daily water use was slightly over 64 gallons. Implementing water conservation measures can reduce average usage to fewer than 45 gallons (NAHB 2006, 3). In addition, water prices have risen steadily (Ogorzalek 2003, 28). For less than a five percent increase in capital costs, affordable housing can use 10 percent to 20 percent less water, saving on utility bills while reducing demand for water (Connelly 2006). Through installation of water efficient fixtures and improved exterior water efficiency, many water conservation benefits can be realized.

Water Efficient Fixtures

Significant water savings can be realized by specifying and installing water-efficient appliances and plumbing fixtures. Studies conducted through Enterprise Community Partners (2007, 21) show "showers and faucets account for approximately 25 percent of indoor water use and toilets account for approximately 20 percent." Saving water reduces energy required for water heating and total consumption, resulting in significant utility savings. The use of low flow toilets, sinks and washers[17] can reduce the consumption of water by 245 gallons per household per day (Edwards & Turrent 2000). Compared with fixtures manufactured before 1992, low-flow fixtures can reduce the amount of water used in showers 75 percent and sinks 50 percent (ECP 2007, 21). Low-flow fixtures are approximately a $100 premium (Magnelli & Sloss 2006). A low-flush toilet uses 40 percent less water, has an initial investment of $150, a payback period of 5 years, and a savings period of 10 years, for a 13 percent return on investment (Wells 2006).

Community Development Corporations frequently use low-flow fixtures (Rather 2006, 31-55). The Oakland Housing Authority (OHA) installed 1,500 ultra-low-flow toilets, 2,100 aerators, and 1,100 low-flow showerheads. In 2002, OHA saved $189,000 in water costs and nearly 36 million gallons of water. An average 3-person household can save $60 annually and 54,000 gallons of water each year with these three items (Ogorzelek 2003, 26). Water efficiency should expand outside of the residence's walls as well.

[17] Toilets should be 1.3 gallons per flush or better, showerheads 2.0 gallons per flush or better, kitchen faucets 1.5 gallons per flush or better, and bathroom faucets 2.0 gallons per flush or better (Magnelli & Sloss 2006; Global Green 2006, 71).

Exterior Water Efficiency

Homes can save significantly on water consumption by using low-water landscape methods, rainwater catchment or graywater sources (ECP 2007, 5). Community Development Corporations frequently implement rainwater recycling in their projects (Rather 2006, 31-55). Cisterns and other rainwater collection systems are a cost-effective method to save water for irrigation (Global Green 2006, 51; NAHB 2006, 131). Green building is more than protecting the environment and saving money; it includes, as in the case of indoor air quality, improving human health.

## Indoor Air Quality

Given the amount of time individuals spend indoors, indoor air quality is essential to any Green building model due to risks to residents' health. Platts-Mills (1995) estimates individuals born after 1995 will spend over 95 percent of their lives inside. As a result, the National Association of Home Builders (NAHB) (2006, 3) reports many Green building consultants cite indoor air quality as the most important feature of Green homes after energy efficiency.

The USCDC has classified indoor pollution as a high environmental risk factor (USCDC 1994). Samet and Spengler (2003, 1489) found "risks for diverse diseases are increased by indoor air pollutants, surface contamination with toxins and microbes, and contact among people at home, at work, in transportation, and in many other public and private places." The publication of *The American Journal of Public Health* special issue on the built environment signals growing recognition of the affects indoor environments have on human health. The emphasis on the built environment indicates a shift toward a more holistic approach to indoor environments and the public's health (Samet & Spengler 2003, 1489). Additionally, it recognizes the many environmental factors that play a role in human health (Samet & Spengler 2003, 1489).

Two milestones facilitated recognition of the of the built environment's importance to health. The initial milestone came when measurements of specific pollutant levels were assessed in indoor air for the first time (Samet & Spengler 2003, 1490). The second occurred as other researchers analyzed those measures, revealing indoor air pollutants played a larger role than outdoor in affecting human health (Samet & Spengler 2003, 1490). Dramatic problems, such as mobile homes that could not be occupied because of extremely high levels of formaldehyde from building materials, indicated construction methods might be to blame (Samet & Spengler 2003, 1490). The health consequences of dampness and mold are a current example. In addition, there are emerging issues such as phthalates, organophosphates, and pyrethroid pesticides (Samet & Spengler 2003, 1489).

Substandard housing conditions, indoor environmental exposures, and environmental smoke exposure contribute and are more prevalent in low-income areas (Gold & Wright 2005). Neighborhoods influence incidence of asthma, with a disproportionate burden in communities of color and impoverished neighborhoods (Spielman *et al* 2006, 102). According to the United States Center for Disease Control, low-income people endure the highest rates of asthma, with many known and suspected triggers linked to conditions in the home (ECP 2007, 3). The increase in asthma has coincided with major changes to the home environment, in part driven by alterations to building design hastened by high fuel costs during the 1970s energy crisis. Modern homes better insulated than was previously the case, often without regard for the affects tighter construction can have on indoor air quality (Jones 1998, 755).

Greening affordable housing mitigates the risk of liability. Many government researchers believe indoor air quality is the next lead paint-type issue in low and moderate income housing (Connelly 2006). Moreover, the United States Department of Housing and Urban Development has over 9,000 court cases involving moisture problems, double the next closest (Doxley 2006). Affordable housing should provide safe, suitable living environment for low-income residents. Safety includes avoiding building methods and materials that harm residents' health, especially those particularly weak such as children, seniors, and individuals with existing respiratory problems and compromised immune systems. A healthy living environment minimizes residents' and workers' toxic material exposure, and uses safe, biodegradable materials as alternatives to hazardous materials (ECP 2007, 6).

Interventions to improve housing are essential to advancing children's health (Chaudhuri 2004, 220). Preventative measures are a simple and effective solution to the problems caused by indoor air, and should be the prime focus in any asthma or allergy management program (Chaudhuri 2004, 220). To facilitate prevention, governments need to set and enforce home building standards regarding indoor air quality (Jones 1998, 761). Reducing exposure to negative health triggers is essential to reducing economic disparities in hospitalizations, emergency room visits, and missed school days due to asthma (Spielman et al 2006, 102). General improvements in living conditions and life opportunities are the only ways to ensure long-term health improvements (Gold & Wright 2005). Samet and Spengler (2003, 1492) postulate if achieving a healthy indoor environment were a specific requirement for buildings, many of the recurring problems of mold, pest allergens, radon, organic compounds, nitrogen dioxide and carbon monoxide could be controlled.

For less than a five percent increase in construction costs, affordable housing developers can make buildings that are healthier to live in, have better indoor air quality, have less toxics and pesticides, increase comfort, and reduce noise pollution (Connelly 2006). “Community-based interventions that target elements of the built environment, such as poor housing conditions, have great potential to address the negative health effects caused by the building environment” (Spielman et al 2006, 107).

As discussed earlier, Energy Star[18] results in increased comfort, even temperatures throughout the house, eliminates drafts, and improves indoor air quality. In addition, Energy Star increases durability, and eliminates water and mold problems by controlling moisture (Doxley 2006). Energy Star bathroom fans exhausted to outside with a humidistat sensor or timer reduce moisture condensation, decreasing the likelihood for indoor mold growth, which studies have found yield odors and pose health hazards. In addition, these fans remove carbon monoxide and carbon dioxide. Energy Star fans use 65 percent less energy on average than standard models and move more air per unit of energy used with less noise[19].

Beyond Energy Star equipment, material selection can have a significant affect on indoor air quality. Affordable housing should use non-vinyl, non-carpet floor coverings in all rooms, such as natural linoleum, laminate, ceramic tile, bamboo, cork, wood or rubber (ECP 2007, 45). (LaRue 2006) (Stromberg 2005, 21). In addition, using paints with little or no volatile organic Compounds improves indoor air quality (LaRue 2006; Magnelli & Sloss 2006; Stromberg 2005, 21). The Green premiums for such actions are little or even zero cost in some cases. Formaldehyde free carpet and cabinets, and low VOC paint do not carry additional costs.

[18] See Note 6.
[19] See ECP 2007, 37; LaRue 2006; Magnelli & Sloss 2006; Global Green 2006, 71; NAHB 2006, 107.

Microwave and stove vents carry an $80 premium, Energy Star bath fans cost approximately $90, and HVAC zone heating and cooling approximately $600 (Magnelli & Sloss 2006).

Allergens and Volatile Organic Compounds are two significant areas of indoor air quality that must be addressed in an effective Green building program.

Allergens

Over the past several decades, researchers have identified numerous indoor allergens that exacerbate and cause allergic diseases (Samet & Spengler 2003, 1491). Various indoor initiants, such ashouse dust mites, molds, fungal spores, and nitrogen dioxide from poorly vented gas-cooking, are associated with asthma (Hasselblad et al 1992).

Currently, insurance companies are attempting to write policies excluding mold liability or simply refusing to provide coverage in states where mold claims are widespread (Samet & Spengler 2003, 1492). Their reluctance to provide service stems from high costs associated with health expenses from mold exposure, particularly the toxic varieties. Molds thrive in warm and humid areas with low sunlight exposure.

Like mold, dust mites thrive in soft furnishings, particularly in warm and humid rooms (Jones 1998, 755). The relationship between molds and dust mites means that, as well as being a risk factor for allergic sensitization, molds are a risk for increased house dust-mite concentrations (Luczynska 1994). Platts-Mills (1997) estimates exposure to mite allergen may trigger attacks in up to 85 percent of asthmatics. Resident exposure to mite allergen, especially infants, may induce the onset of asthma itself (Call et al 1992, 865).

Similar to dust mites, cockroaches have been associated with the manifestation of symptoms in individuals with allergic asthma and up to 60 percent of asthmatics test positive to cockroach allergen (Kuster 1996). Rosenstreich (1997) measured concentrations of the allergen in dust taken from 476 homes situated in various inner-city locations in the USA. He concluded the problems of cockroach sensitization might be particularly severe amongst the residents of poor quality inner-city housing, as these homes provide an ideal environment in which cockroaches and other allergens thrive.

Sensitization to indoor allergens is strongly associated with the development of asthma. Given the evidence that exposure to allergens in infancy may cause asthma, indoor allergen avoidance is the most effective strategy for prevention (Jones 1998, 759). Recent clinical trials have shown that simple avoidance measures are effective in reducing asthma morbidity (Jones 1998, 761). Similarly, recent evidence indicates altering the home environment may decrease exposure to indoor allergens, reducing symptoms of atopic asthma in urban children (Morgan et al 2004).

Carpet attracts allergens, so removal of carpet and replacement with sealed flooring, such as ceramic tile, wood and laminate, is an effective means to reduce allergic symptoms (ECP 2007, 35; Jones 1998, 759). The most effective treatment for mite populations, however, is a decrease in overall levels of air humidity (Jones 1998, 760; Global Green 2006, 60). Sizing heating, ventilation and air conditioning systems in accordance with Air Conditioning Contractors of America Manuals D, J and S[20] prevents short cycling and ensures adequate dehumidification. This ensures proper sizing of the cooling system, accounting for orientation,

[20] The ACCA manuals are required under the 2003 International Residential Building Code. ACCA manual D presents the methods and procedures that should be used to design residential duct systems. ACCA manual D also includes information about duct system efficiency and the synergistic interactions between the duct system, the envelope, the HVAC equipment, the vents and the household appliances. Indoor air quality, noise control, testing and balancing also are discussed. ACCA Manual J is primarily a load calculation manual. ACCA Manual S is a comprehensive guide for selecting and sizing residential heating and cooling equipment. ACCA Manual S documents the procedures that should be used to select and size residential cooling equipment, furnaces and heat pumps.

window design and insulation rating, and can result in reduced costs for mechanical equipment[21]. While considered a type of allergen in some cases, volatile organic compounds have many other attributes that warrant further exploration.

Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are chemicals containing carbon molecules volatile enough to evaporate from material surfaces into indoor air at normal temperatures. VOCs may pose health hazards to residents and workers, reacting with sunlight and nitrogen to form ground-level Ozone, which damages ecosystems and lung tissue, reducing lung function and sensitizes the lungs to other irritants (ECP 2007, 34; NAHB 2006, 3). Indoor pollution sources are generally a far more significant contributor to total personal exposures to toxic VOCs than are releases by some industrial sources into outdoor air (Wallace 1987). The elderly, those with weak immune systems, and young children are most prone to the effects of VOCs (Global Green 2006, 71). Common sources of VOCs include solvents, floor adhesives, particle-board, wood stain, paint, cleaning products, polishes, and room fresheners. Levels of most VOCs can be five to ten times higher indoors than outdoors (Samet 1990; Global Green 2006, 71; USGBC 2007, 4).

High concentrations of VOCs and formaldehyde have been associated with asthma, as well as asthmatic breathlessness (Wieslander et al 1997). Particle- and fiber-board often emit formaldehyde, a VOC that can cause watery eyes, nausea, coughing, chest tightness, wheezing, skin rashes, allergic reactions and burning sensations in the eyes, nose and throat. The World Health Organization International Agency for Research on Cancer lists formaldehyde as a known carcinogen because evidence indicates it causes nasopharyngeal cancer in humans (ECP 2007,

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[21] See ECP 2007, 37; Magnelli & Sloss 2006; Global Green 2006, 69; and NAHB 2006, 101.

35; Wells 2006). Dioxin is increased through manufacturing of many building materials, leading to increased rates of cancer (Wells 2006).

A better indoor environment may be achieved by selecting building construction, building materials, and indoor fittings on the principle that the emission of pollutants such as VOCs and formaldehyde should be as low as reasonably achievable. The use of insulation materials that emit formaldehyde should be avoided (Jones 1998, 761; Global Green 2006, 71). In addition to providing a haven for allergens, carpet often emits a variety of VOCs (ECP 2007, 35; Wells 2006). As discussed earlier, the premium to install low- or no-VOC materials and paint is often zero. There are several third-party verifiers available to assist with selecting low- or no-VOC materials, including the Carpet and Rug Institute's Green Label program, and the Green Seal program for paint. Community Development Corporations often use low- and no-VOC construction materials, paint, adhesives, caulk and cabinets, and no carpet (Rather 2006, 31-55).

Though construction methods have a significant role in Green building, many Green building goals can be achieved through site selection, design and landscaping.

**Site Selection, Site Design, and Landscape Ecology**

Research suggests site selection, site design, and landscape ecology are necessary components of Green building and thus warrant inclusion in the model. Sustainable design and site planning minimize environmental site impacts, enhance human health, reduce construction costs, maximize energy, augment water and natural resource conservation, improve operational efficiencies, and promote alternative transportation (ECP 2007, 5). Placing homes near community amenities, such as public transportation, to create walkable neighborhoods, results in stronger communities and more opportunities fore residents while reducing sprawl-related transportation impacts (ECP 2007, 4). For less than a 5 percent increase in initial costs, affordable housing providers can make buildings that have easier to maintain landscapes with more amenities, while infiltrating storm-water, often reducing costs. (Connelly 2006). Each of the following sections discusses a particular aspect of site selection, site design and landscape ecology for inclusion in the model.

### Infill, Brownfield and Greyfield Sites

Infill projects, public housing improvements, brownfield and greyfield redevelopment, and other types of urban renewal provide opportunities to reuse existing resources, including transportation networks & utility infrastructure, human capital, social networks, and building materials (ILSR 1998). Redevelopment avoids municipal budget strain because cities avoid new, distant service routes and infrastructure lines (ECP 2007, 13).

"Locating projects in communities with services strengthens those communities and residents' ties to society" (ECP 2007, 13). Reusing previously developed properties in depressed areas as viable commercial and residential lots reduces the need for Greenfield development and its associated infrastructure, provides reinvestment in blighted areas, generates tax revenues, and creates jobs (Fitzgerald & Leigh 2002). In targeting infill sites, affordable housing developers may also realize proximity benefits to transit, services and employment.

### Proximity to Transit, Services, and Employment

Pedestrian and transit oriented neighborhoods include smaller streets and less land designed to accommodate automobiles. The neighborhoods offer residents many services, parks and employment opportunities within walking and biking distance. They encourage a healthier quality of life and lower dependence on cars, reducing car ownership costs and the need for garages and other parking areas (ECP 2007, 13). While a rehab site could be exempt from many of these requirements, a housing developer could still select a site to rehab based on many of the criteria: whether the location already has existing infrastructure, whether the site is within a half-mile of at least four community and retail facilities, and within one-quarter mile of transit (LaRue 2006). Proximity to these services and establishments reduces the occupants' cost of living while improving quality of life.

Storm Water Management

Every building site is part of a watershed. All development contributes to watershed degradation through non point source pollution. Pavement also prevents rainwater from infiltrating the ground and elevating the site's natural water table (Global Green 2006, 50). Erosion and sedimentation control maintains topsoil, and reduces pollution, storm water runoff and sediment runoff. Soils are often compacted during construction, leaving them less able to absorb water and resistant to plant root penetration. Controlling erosion avoids storm water related problems that can delay construction, cause environmental damage and negatively impact downstream properties (ECP 2007, 18). Storm water runoff also reduces aquifer recharge (ECP 2007, 31).

"Managing water onsite to reduce, filter or slow its flow into municipal treatment systems is an increasingly important goal of many green buildings" (Stromberg 2005, 21). Affordable housing should use permeable surfaces wherever possible, like building pedestrian surfaces with loose aggregate, wooden decks, or paving stones (Global Green 2006, 50). Water permeable concrete walkways have a $120 Green premium (Magnelli & Sloss 2006). Use of native and adaptive vegetation, as discussed in the next section, provides an excellent method to achieve improved stormwater management while realizing other benefits.

Use of Native and Adaptive Vegetation

Landscaping water use accounts for approximately 50 percent of a home's total water needs. Thoughtful selection and placement of plants can reduce heating and cooling loads, provide habitat, and minimize the heat island effect (NAHB 2006, 62). Native vegetation compensates for the climate and controls erosion, sediment, dust and pollution. Native plants are also resistant to local disease, insects and nutrient levels, reducing fertilizer, pesticide and herbicide use[22]. Community Development Corporations often use xeriscaping and native plants to improve their site ecology while reducing other costs, such as irrigation (Rather 2006, 31-55).

Green housing also includes what happens to materials once they leave the construction site and during the manufacturing process.

## Building Ecology, Waste, and Recycling

While site selection, site design, and landscape ecology Green the building site, additional measures must be taken in the structure to achieve the goals of Green building. Building ecology, waste and recycling includes site recycling and reducing use of raw material. More than 210 million tons of solid waste is generated and disposed of annually, 136 million of which is attributed to construction site and building use waste (ECP 2007, 3; NAHB 2006, 86). Buildings are responsible for 25 percent of the world's timber harvest and 30 percent to 40 percent of raw materials produced, resulting in deforestation and habitat loss (ECP 2007, 3; Wells 2006; NAHB 2006, 86). The amount of job site waste resulting from construction of the

[22] See ECP 2007, 19; Global Green 2006, 49; and NAHB 2006, 3.

average American home (2,320 square feet) is four pounds per square foot of conditioned space, totaling about 8,000 pounds and taking up 50 cubic yards of landfill space (NAHBRC 2001; NAHB 2006, 2).

Reducing, reusing and recycling building materials conserve natural resources and reduce emissions associated with manufacturing and transporting raw materials. Many techniques and building products on the market contribute to more durable, healthy, and resource-efficient buildings (ECP 2007, 6). For five percent or less, affordable housing can include durable buildings durable that cost less to maintain, recycle demolition and construction waste, and use recycled materials during construction (Connelly 2006). Recycling on site and reducing consumption of raw materials are two important methods to achieving Green building goals.

Site Recycling

The current development climate favors quick removal of structures and disposing of the waste in inexpensive landfills (NAHBRC 2001). Conventional mechanical demolition and landfilling is not sustainable because it does not take advantage of existing assets. Discarding usable building materials causes more use of virgin materials. Mining, logging and chemical manufacture of virgin materials often result in environmental degradation. The existence of a secondary construction building materials market indicates the old materials have value. Beyond missed opportunities to gain money from the sale or reuse of materials, public costs include landfill capital and operating costs, which are often publicly subsidized. While only 25 percent to 30 percent of the construction and demolition debris is currently recycled, evidence indicates efficient waste management could divert up to 75 percent from landfills (Leigh & Patterson 2006, 217).

Deconstruction opens a variety of opportunities to recycle materials. Leigh and Patterson (2006, 220) found “initial deconstruction costs, including labor, are higher than the initial costs for traditional demolition methods. Considering material sales and savings from avoiding landfilling, however, deconstruction projects cost less than traditional demolition projects.” Builders can reuse salvaged lumber for nonstructural applications, or remill it for flooring or furniture. Other materials can be reused on-site or recycled. Builders can crush concrete and use it as aggregate or fill, grind asphalt shingles for roads or driveways, and pulverize drywall for use as a soil amendment (LaRue 2006; Leigh & Patterson 2006, 218; Global Green 2006, 83). Many local non-profit corporations, such as Habitat for Humanity, will accept salvaged materials.

Builders should also develop and implement a construction waste management plan. It can cut waste by two-thirds, creating potential cost savings and reducing the burden on landfill space. It should set a goal to recycle or salvage a minimum of 50 percent of construction, demolition and land-clearing waste (NAHB 2006, 90). While recycling is important, perhaps the more effective means of reducing material impacts is to simply cut the amount needed for construction.

### Reducing Amount of Raw Material

Several methods are available to reduce the amount of raw material involved in affordable housing. For example, the average three-bedroom house is 1,890 square feet. Building a smaller house results in far less material use while still providing a safe, healthy environment (Global Green 2006, 79; NAHB 2006, 70). Choosing rehabilitation over new construction is another effective way to reduce consumption of raw material. Redevelopment encourages compact development, and reuses existing infrastructure, local business and employment, meeting a variety of sustainability goals. Neighborhoods and residents benefit socially from building community capacity, historic preservation, improving quality of life, and reducing blight (Leigh & Patterson 2006, 218). Reuse of existing structures reduces the need for new materials and utilizes embodied energy (ECP 2007, 16).

Use of recycled content materials reduces the negative impact resulting from extraction and processing of virgin materials. “Many recycled content materials have additional benefits, which yield better results and a stronger final product” (ECP 2007, 30). Engineered wood products can help optimize resources by using materials in which 50 percent more of the log is converted into structural lumber than conventional dimensional lumber (NAHB 2006, 1). In addition, mills make engineered wood products from almost any kind of tree, preserving old growth forests. These products resist warping, cracking, and splitting better than dimensional, increasing durability (Global Green 2006, 81). With less than ten percent of old-growth forest remaining in the United States, the use of Forest Stewardship Council certified wood or other third party verifier encourages forestry practices tat are environmentally responsible, socially beneficial and economically viable. Engineered wood products are often made from salvaged and fast-growth wood (ECP 2007, 31; Global Green 2006, 83; NAHB 2006, 90).

Modern framing techniques represent an additional opportunity to reduce raw materials use. Using manufactured roof trusses, floor trusses and wall panels reduce lumber use by 25 percent and cut scrap generation. Use of preassembled components can cut total construction costs by 15 percent (WTCA 1996; Global Green 2006, 81). Structurally Insulated Panels (SIPs) allow superior indoor air quality (no condensation in wall cavity and organically inert), downsized HVAC, conserve resources by using strand board from fast growing trees, improved structural strength allowing for more open design and natural lighting. In addition, SIPs improve community acceptance as they have some advantages of plant manufacturing without the stigma of manufactured or modular housing (Phillips 2006, 10; NAHB 2006, 79).

Optimal Value Engineering (OVE) uses common lumber dimensions, wider spacing between studs and joists, inline framing and open floor plans to reduce material use (Global Green 2006, 80). While maintaining structural integrity, OVE saves three percent to five percent on framing costs, has two percent to five percent better energy efficiency, and results in less wood and consumptive waste (NAHB 2006, 72).

In addition, builders can use recycled content in insulation, fly ash in concrete sidewalks, refinish cabinetry, install countertops made from strawboard, and use carpet squares that are nearly 100 percent recycled and nearly 90 percent recyclable (LaRue 2006). Community Development Corporations frequently use recycled materials, and sustainable and locally produced materials (Rather 2006, 31-55). Integrated design, however, is essential to effectively implementing many of the aspects of Green building discussed.

**Integrated Design**

An integrated design process, including interdisciplinary involvement and a whole-systems approach, is necessary in the Green building model. Effective green building programs clearly identify goals, outline the decision making process, identifying a multi-discipline team, and provide documentation that decisions are thoughtful, strategic and read like a logical argument for the Green methods used (Magnelli & Sloss 2006). Green affordable housing programs should integrate the architecture with the mechanical, electrical an plumbing systems to create synergies; brings together architects, engineers, others across disciplines and technologies from project initiation; work to meet project goals from beginning; and consider multiple solutions to design problems; reducing chances of costly change orders (Connelly 2006; Wells 2006). The following sections provide support for the inclusion of integrated design in the model.

Interdisciplinary Involvement

Research indicates successful Green affordable housing approaches the building environment with multidisciplinary teams (Samet & Spengler 2003, 1492). Many builders may need additional support to integrate effectively additional green measures into their home designs, and to ensure each subcontractor constructs these designs appropriately (USGBC 2007, 8). Contractors represent a weak link when it comes to building Green because they often lack experience with the specific needs of Green design (Rather 2006, 81). Several Green building institutions, including the United States Green Building Council, consider third-party verification essential to ensuring all Green building goals are met (USGBC 2007, 8). Just as a jurisdiction should consult multiple disciplines, it should consider multiple systems in a inclusive manner.

Whole Systems Approach

With a written plan using a holistic and total-systems approach to the development process, builders can promote good health and livability through the building's life cycle while enhancing affordability (ECP 2007, 5). Successful Green homes start in the design phase; materials selection has a significant bearing on whether some other Green building measures should be implemented (NAHB 2006, 1). For example, significant moisture problems can occur in a rehab that meets Energy Star standards without adequate fresh air ventilation (LaRue 2006). Green building reduces the risk of cost over-runs because they are often higher quality projects, require field verification and extra project supervision, and the more detailed plans result in tighter specifications (Connelly 2006).

Builders should conduct an energy analysis of the existing building condition and identify cost-effective energy improvements. Builders can implement those improvements with a ten year or less payback. In moderate rehabs, the financial benefits of making some improvements vary due to differing building conditions and the local climate. Therefore, the most effective practice is to conduct a building assessment to determine the unique conditions of the building (ECP 2007, 24; LaRue 2006).

Material selection requires careful study. A product can be renewable, but may require large amounts of energy to transport. Builders should use life-cycle analysis, which “covers environmental impacts at all stages of manufacture and use: raw material acquisition, product manufacturing process, home building process, home maintenance and operation, home demolition, and product reuse, recycling and disposal” (NAHB 2007, 2).

Green building does not stop with the conclusion of construction; housing providers must provide the owners and occupants information to ensure the Green building features function at optimum levels.

**Owner and Occupant Education**

Poor ownership practices can easily negate other Green building features of a home and must be included in the Green building model to assure ongoing success. Operation and maintenance practices affect the building owner’s costs and residents’ health, comfort and safety. Sustainable building operation and maintenance practices enhance resident health and operational savings. Successful building performance integrates operation and maintenance plans, education, and cost-effective, low-maintenance design (ECP 2007, 6; NAHB 2006, 3). Occupant education is essential to keeping allergens suppressed, as the residents must understand how to maintain performance of the various Green home aspects. Good education provides a non-pharmaceutical option to managing asthma, and is taught easily in the home (Jones 1998, 760).

Informing residents about the proper use of equipment such as thermostats and ventilation fans prevents wasteful decisions (Global Green 2006, 110). Builders should educate residents on Green housekeeping practices, such as low-toxicity detergents, ventilation, and the importance of addressing evidence of pest and moisture problems early (Global Green 2006, 110; NAHB 2006, 3).

Owner orientation works best when conducted in stages: covering basic things like locks, windows and thermostats first, then all major shut-offs, and lastly remaining items or unique Green features (LaRue 2006; NAHB 2006, 151). Builders should conduct training and create manuals in the person's native language to ensure understanding (Global Green 2006, 110).

The National Association of Home Builders (2006, 149) suggests including the following information in the manual and training:

- ❐ Narrative detailing importance of operations and maintenance to keep home green;
- ❐ Any Green certificates;
- ❐ Warranty & instructions for equipment and appliances;
- ❐ Household recycling opportunities;
- ❐ Info to purchase energy from renewable provider;
- ❐ Benefits of compact fluorescent light bulbs;
- ❐ List of habits and actions to optimize water and energy use;

- ❒ Local transportation options;
- ❒ Clear labeling of safety valves and controls;
- ❒ Green items included in the home;
- ❒ Maintenance Checklist;
- ❒ Proper handling and disposal of hazardous materials; and
- ❒ Information on organic pesticides, fertilizers, environmental cleaning products

**Model Summary**

This extensive review of the literature reveals a common set of characteristics associated with a successful model for Green housing rehabilitation and new construction program under CDBG and HOME. The ideal type categories developed for an effective program are as follows:

- ❒ Energy Systems
- ❒ Water Conservation
- ❒ Indoor Air Quality
- ❒ Site Selection, Design, and Landscape Ecology
- ❒ Building Ecology, Waste, and Recycling
- ❒ Integrated Design
- ❒ Owner and Occupant Education

**Table 3.2** provides detailed information about each element of the model and connects the categories to the supporting literature.

**Table 3.2: Conceptual Framework of an Affordable Green Housing Program**

| Ideal Type Categories | Sources | |
|---|---|---|
| **Energy Systems**<br>▪ Whole house energy efficiency certification<br>▪ Energy efficient lighting, fixtures and appliances<br>▪ Energy efficient heating, ventilation and air conditioning systems (HVAC)<br>▪ Tight construction<br>▪ Passive solar design | Connelly 2006<br>Global Green 2006<br>Quigley 2004<br>Rather 2006<br>Stromberg 2005<br>USGBC 2007<br>Wells 2006<br>USHUD 2007 (3)<br>USDOE 1999 | Doxley 2006<br>ECP 2007<br>LaRue 2006<br>Magnelli & Sloss 2006<br>NAHB 2006<br>NEADA 2004<br>NLIEC 2003<br>Phillips 2006<br>Oak Ridge 2007 |
| **Water Conservation**<br>▪ Water efficient fixtures<br>▪ Exterior water efficiency | Connelly 2006<br>Global Green 2006<br>LaRue 2006<br>NAHB 2006<br>Magnelli & Sloss 2006<br>Ogorzalek 2003 | Rather 2006<br>USGBC 2007<br>Wells 2006<br>ECP 2007<br>Edwards & Turrent 2000 |
| **Indoor Air Quality**<br>▪ Allergens and mold<br>▪ Volatile Organic Compounds | Connelly 2006<br>Global Green 2006<br>Rather 2006<br>Stromberg 2005<br>Doxley 2006<br>Gold & Wright 2005<br>Jones 1998<br>Luczynska 1994<br>Morgan *et al* 2004<br>Platts-Mills 1997<br>Rosenstreich *et al* 1997<br>Samet 1990<br>USCDC 1994<br>Wieslander *et al* 1997 | USGBC 2007<br>Wells 2006<br>Call *et al* 1992<br>Chaudhuri 2004<br>ECP 2007<br>Hasselblad *et al* 1992<br>Kuster 1996<br>Magnelli & Sloss 2006<br>NAHB 2006<br>Platts-Mills 1995<br>Samet & Spengler 2003<br>Spielman *et al* 2006<br>Wallace 1987<br>LaRue 2006 |
| **Site Selection, Site Design, and Landscape Ecology**<br>▪ Infill, brownfield and greyfield sites<br>▪ Proximity to transit, services and employment<br>▪ Stormwater management<br>▪ Native and adaptive vegetation | Connelly 2006<br>Global Green 2006<br>Rather 2006<br>Stromberg 2005<br>ILSR 1998 | ECP 2007<br>Fitzgerald & Leigh 2002<br>LaRue 2006<br>Magnelli & Sloss 2006<br>NAHB 2006 |
| **Building Ecology, Waste, and Recycling**<br>▪ Site recycling<br>▪ Reducing use of raw material | Connelly 2006<br>Global Green 2006<br>Rather 2006<br>Wells 2006<br>WTCA 1996<br>Phillips 2006 | ECP 2007<br>LaRue 2006<br>Leigh & Patterson 2006<br>NAHB 2006<br>NAHBRC 2001 |
| **Integrated Design**<br>▪ Interdisciplinary involvement<br>▪ Whole-systems approach | Connelly 2006<br>Wells 2006<br>Rather 2006<br>USGBC 2007<br>Samet & Spengler 2003 | ECP 2007<br>Magnelli & Sloss 2006<br>NAHB 2006<br>LaRue 2006 |
| **Owner and Occupant Education**<br>▪ Use of systems and features<br>▪ Native language<br>▪ Green housekeeping | Global Green 2006<br>ECP 2007<br>NAHB 2006 | Jones 1998<br>LaRue 2006 |

## Chapter Summary

The review of scholarly literature indicates that there are a variety of issues associated with the development of Green building practices under the CDBG and HOME programs. The issues include maximizing efficiency in energy systems, implementing water conservation, Improving indoor air quality, using sites more efficiently, constructing ecologically sound building envelopes, establishing an integrated design process, and providing residents with the knowledge to maintain building performance. The literature reviewed specifically addresses the relationship between Green building, and the goals and objectives of various government funding programs, and the need to change programs rules to reflect those intents.

## Chapter 4: Methodology

The purpose of this research is to gauge how well Community Development Block Grant (CDBG) and HOME Investment Partnership (HOME) local jurisdictions compare to the ideal model for Green building under those programs. The categories from the conceptual framework are operationalized through the survey questions. Additionally, this chapter describes the research methodology, unit of analysis, population, the survey instrument, and the instrument's potential to serve as a template for implementing the model on the national level.

### Survey Research

The Community Development Block Grant (CDBG) and HOME programs are assessed using survey questionnaires directed to administrators grant recipient in Texas. The questionnaire assesses each administrator's perceptions of Green building in the jurisdiction's housing construction programs. Each survey question addresses a particular sub-topic for an ideal model component. For example, the question statement "My jurisdiction requires vents in all kitchens and bathrooms be installed and vented to the outside" is designed to assess how well new construction and/or rehabilitation programs reduce the potential for mold and allergens under the *indoor air quality* component. The operational relationship between the survey question statements and each model component and subtopic is shown in **Table 4.1**.

### The Survey as a Template

When taken together, the survey question statements provide a snapshot of Green building under the CDBG and HOME programs. In addition, the coverage offered by the survey question statements could provide a template for establishing a Federal standard for Green building. In particular, the use of third-party verifiers for many of the items, such as Energy Star certification, provides administrators an opportunity to integrate Green standards easily in construction bid specifications without becoming technical experts in Green building[23].

**Research Technique**

The study uses survey research as the assessment technique because it provides the best feasible method to obtain administrator perceptions of each jurisdiction's Green building efforts under the Community Development Block Grant (CDBG) and HOME programs. Salant and Dillman (1994, 9) indicate a major strength of survey research is its unobtrusive nature. Respondents can complete surveys at their leisure (Salant & Dillman 1994, 9). Babbie (2001, 269) adds that survey research is associated with high reliability due to a stable research format, the questionnaire, which can collect information efficiently from numerous subjects. Survey research allows collection of the large amount of data necessary to assess Green construction practices in affordable housing under the CDBG and HOME programs, satisfying the research purposes. In addition, the conceptual framework supplies the organizational structure for the survey questions, and the results of the survey will lend evidence to develop recommendations.

Although associated with high reliability of results, survey research is susceptible to challenges of validity. Babbie (2001, 225) explains that poor participation in the survey instrument by subjects may result in data unrepresentative of the population. Further weakening validity, Salant and Dillman (1994, 13) explain that response scales may not fully assess the topic of inquiry. Babbie (2001, 269) also warns survey results are subject to challenges of validity, because surveys rely on people to recall actions.

[23] This method was used by the City of San Marcos, TX as part of their HOME Owner Occupied Assistance program for Fiscal Year 2005. The City placed many of the items appearing in the survey instrument as bid alternates.

To combat weaknesses inherent in survey research, three methods are used. To prevent poor survey participation, a second request for survey completion will be sent to those who do not return the surveys by the initial due date (Babbie 2001, 225). Second, the survey instrument will be pretested to address biased questions or incomplete response scales by two individuals with extensive experience with Green building, and the HOME and CDBG programs. Finally, selection of the local program administrator as the survey recipient minimizes recall error, because he or she serves as the technical expert and policy advisor for the local CDBG and HOME program funds.

Although it is preferable to have multiple sources of data to corroborate findings (Yin 1994, 92), time and financial limitations do not permit a more in-depth study.

**Benchmarks**

A benchmark of 80 percent of respondents reporting they “always” or “mostly” follow the questionnaire statement determines whether the jurisdictions align with each component of the Green building model. While the percentage is essentially arbitrary, to purport that a simple majority or even an overwhelming majority is ideal would be laughable. In addition, research seems to indicate that such a benchmark is achievable, as nearly every questionnaire item has a low or no cost method of complying. For example, while some alternative building methods are more expensive, such as insulated concrete forms (ICF), optimal value engineering often costs less. The two exceptions to the 80 percent benchmark are whole-house Energy Star certification and testing for building tightness. These are set at 75 percent because they were the most expensive improvements and the scope of some rehabilitation projects would make such efforts impractical. Because the benchmark percentage is arbitrary, there is some flexibility in interpreting results that fall within a few percent of it.

**Table 4.1: Operationalization of the Conceptual Framework**

| **Ideal Type Categories** | **Questionnaire Item** | **Benchmark (respond always or mostly)** |
|---|---|---|
| **Energy Systems** | | |
| Whole house energy efficiency certification | My jurisdiction constructs homes to be Energy Star certified. | 75% |
| Energy efficient lighting, fixtures and appliances | My jurisdiction installs Energy Star certified lighting and fixtures.<br><br>My jurisdiction installs Energy Star certified appliances. | 80%<br><br>80% |
| Energy efficient heating, ventilation and air conditioning systems (HVAC) | My jurisdiction installs Energy Star certified HVAC systems. | 80% |
| Tight construction | My jurisdiction requires use of and verification of tight construction, such as a blower-door test. | 75% |
| Passive solar design | My jurisdiction pre-wires houses so that photovoltaic systems (solar energy) can be installed in the future.<br><br>My jurisdiction uses passive solar design, such as maximizing sunlight for lighting and shading windows exposed to afternoon sun. | 80%<br><br>80% |

| | | |
|---|---|---|
| **Water Conservation** | | |
| Water efficient fixtures | My jurisdiction installs low or ultra-low flow water fixtures in bathrooms and kitchens. | 80% |
| Exterior water efficiency | My jurisdiction installs rainwater harvesting systems. | 80% |
| **Indoor Air Quality** | | |
| Allergens and mold | My jurisdiction sizes and installs HVAC systems according to ACCA Manuals D, S and J.<br><br>My jurisdiction installs vents in all kitchens and bathrooms, and vents them to the outside.<br><br>My jurisdiction requires installation of Energy Star certified vents.<br><br>My jurisdiction installs humidistat or timer switches on bathroom vents. | 80%<br><br>80%<br><br>80%<br><br>80% |
| Volatile Organic Compounds | My jurisdiction installs floor coverings free from formaldehyde and other volatile organic compounds (VOC), such as Green Label certified.<br><br>My jurisdiction installs sealed, non-vinyl floors, such as linoleum, ceramic tile, laminate, or cement rather than carpet.<br><br>My jurisdiction uses low or no volatile organic compounds (VOC) in paint, such as those that are Green Seal certified.<br><br>My jurisdiction requires all materials used in construction, such as composite woods, caulks, and adhesives, not contain formaldehyde or other volatile organic compounds (VOC). | 80%<br><br>80%<br><br>80%<br><br>80% |
| **Site Selection, Site Design, and Landscape Ecology** | | |
| Infill, brownfield and greyfield sites | My jurisdiction selects sites in established neighborhoods with existing infrastructure. | 80% |
| Proximity to transit, services and employment | My jurisdiction selects sites that are within ¼ mile of transit.<br><br>My jurisdiction selects sites that are within ½ mile of at least four community services or retail facilities, such as a grocery store, day care or health clinic. | 80%<br><br>80% |
| Stormwater management | My jurisdiction revegetates the site following construction.<br><br>My jurisdiction installs water-permeable surfaces on all hardscapes, such as using permeable cement for driveways and walkways. | 80%<br><br>80% |
| Native and adaptive vegetation | My jurisdiction requires that all landscaping be xeriscaping, or use native/adaptive plants. | 80% |

| Building Ecology, Waste, and Recycling | | |
|---|---|---|
| Site recycling | My jurisdiction deconstructs homes rather than demolishes, and salvages, recycles or reuses the materials when possible. | 80% |
| | My jurisdiction requires a construction waste management plan that mandates at least 50% of construction and site waste be recycled or salvaged. | 80% |
| Reducing use of raw material | My jurisdiction builds or rehabilitates housing units that are only less than 1,890 square feet. | 80% |
| | My jurisdiction favors rehabilitation of existing housing units over constructing new units. | 80% |
| | My jurisdiction uses recycled or reconstituted content materials when available, such as engineered wood and fiber cement siding. | 80% |
| | My jurisdiction uses wood materials certified as coming from fast-growth forests or remilled salvage wood, such as through the Forest Stewardship Council. | 80% |
| | My jurisdiction uses preassembled structural components, such as manufactured roof trusses and preassembled walls. | 80% |
| | My jurisdiction uses alternative building methods, such as structurally insulated panels (SIP), Optimal Value Engineering (OVE) and Insulated Concrete Forms (ICF). | 80% |
| **Integrated Design** | | |
| Interdisciplinary involvement | My jurisdiction consults a multi-discipline team in designing new housing units and rehabilitation, such as architects, mechanical systems professionals and planners. | 80% |
| Whole-systems approach | My jurisdiction has and uses a written plan to encourage Green building practices in new construction and rehabilitation. | 80% |
| | My jurisdiction conducts an analysis of each housing unit for rehabilitation to assess which Green building methods are cost-effective. | 80% |
| | When information is available, my jurisdiction uses life-cycle analysis of environmental impacts to select materials. | 80% |
| **Owner and Occupant Education** | | |
| Use of systems and features | My jurisdiction conducts a training session with the housing unit occupants to explain how all home features work. | 80% |
| | My jurisdiction provides a written guide to the housing unit that explains how all home features work. | 80% |
| Native language | My jurisdiction provides training sessions and guides in the occupants' native language. | 80% |

| | | |
|---|---|---|
| Green housekeeping | My jurisdiction provides the occupants information on environmentally responsible ways of cleaning the housing unit. | 80% |
| | My jurisdiction provides information on other methods the occupants can implement that achieve environmental goals, such as area recycling programs, renewable energy providers and proper handling of hazardous materials. | 80% |

Each question has three responses: one concerning rehabilitation, another concerning reconstruction, and the last concerning new construction. The three activities are separated because jurisdictions often conduct one, but not the other under their respective programs. In addition, circumstances for each differ, as rehabilitation often has additional complexities involved in using an existing structure. Also, separate data sets provide additional opportunities for further research. **Attachment A** contains a copy of the 43-question survey instrument. The questionnaire was distributed by electronic mail with a link to an Internet-based survey. If an email address could not be located or was invalid, the survey was sent by facsimile or conventional mail. Similar alternatives were used for respondents reporting technical difficulty with the electronic survey.

**Unit of Analysis**

The study's unit of analysis is program administrators for CDBG and HOME grant recipients in Texas. The program administrator for each grant recipient was surveyed because they have the most technical and institutional knowledge of their housing construction programs.

**Population**

The population for the study is CDBG and HOME grant recipients in Texas. The sampling frame is the list of 75 CDBG and 42 HOME grant recipients maintained by the US

Department of Housing and Urban Development (HUD), a federal government agency responsible for administering each grant. The list maintained by HUD is the most complete and accurate existing list of the study population and is believed to contain virtually all members of the study population.

Surveying the sampling frame is preferable to selecting a sample, because it will more likely provide an accurate representation of the study population (Babbie 2001, 178). In the current study, the sampling frame is a manageable size; therefore, all members will be surveyed.

**Human Subjects Protection**

This survey research is an exempt category of research under 45 CFR, Part 46, Section 101(b)(3). The research involves survey procedures on appointed public officials.

**Statistics**

Descriptive statistics will be used to summarize the survey data. The frequency and percentages of responses for each survey item were calculated to describe the central tendency. The descriptive statistics provide a digestible snapshot of the survey data for development of recommendations. For example, a higher percentage responding “always” or “mostly” for “My jurisdiction requires use of and verification of tight construction, such as a blower-door test” would indicate that many cities have implemented tight construction in their programs, and that those that have not are missing an apparent opportunity. Conversely, a low percentage might indicate the programs are unaware of the benefits of tight construction, believe it is not cost-effective, or perhaps lack developers in the area experienced with such methods. This data is not only useful for providing the assessment to determine consistency with the ideal Green building model under this research, but could also be used in future research to analyze why the respondent’s did or did not require an aspect of Green building in the jurisdiction’s housing construction program.

The following chapter, Chapter 5, reports the survey results and reflects upon Texas grant recipients’ adherence to the model.

# Chapter 5: Results

The purpose of this chapter is to provide an analysis of the results of the survey instrument assessing the state of Green building in Texas Community Development Block Grant and HOME programs discussed in chapter four. These results are used as the basis to make recommendations on how Texas local jurisdictions can improve their Green building efforts and create superior affordable housing and improved quality of life for the occupants. Discussion of the results frequently references differences between rehabilitation, reconstruction and new construction. **Appendix A** includes responses segregated into the three construction types.

## Response Rate

Surveys were sent by electronic mail to 76 Community Development Block Grant (CDBG) and HOME Investment Partnership (HOME) coordinators for Texas local jurisdictions. Of the 76 surveys distributed, 36 were completed and returned. Of those returned, 35 were CDBG recipients and 19 were HOME recipients. Therefore, there was a 47.4 percent overall response rate achieved using this survey. For CDBG recipients, the response rate was 46.7 percent, while the rate for HOME recipients was 45.2 percent. There were more programs than respondents because each respondent often had more than one program. For example, a jurisdiction could respond for a rehabilitation program and a new construction program, but not conduct reconstruction. There were 28 rehabilitation programs, 16 reconstruction programs, and 13 new construction programs, for 57 total programs in the 36 responding jurisdictions. Four records were incomplete and not considered as part of this research.

The limited number of responses may be attributed to the two-week time frame allowed for responses.

**Energy Systems**

While implementation was better for energy systems than other model categories, grant recipients did not meet any of the benchmarks. For all subcategories except photovoltaic pre-wiring, at least a few respondents for each construction type indicated they always or mostly implemented the model. The limited adoption verifies it is possible to include more efficient energy systems on a restricted budget. **Table 5.1** summarizes the responses regarding energy systems.

The influence of the federal Energy Star program is visible in the survey results, though still disappointing as the benchmark remained out of reach. Whole-house energy efficiency certification did not fair well, with only 24.6 percent of respondents indicating their jurisdiction always or mostly requires Energy Star certification. Interestingly, results for third party verification of building tightness were almost 20 percentage points lower than whole-house energy efficiency certification even though it is often required for the certification. This may indicate that those jurisdictions requiring Energy Star certified construction do not understand the details involved.

Between one-third and a little more than one-half of respondents reported their jurisdictions always or mostly install energy efficient fixtures, appliances and HVAC systems. The higher results compared to whole-house certification may stem from the relatively low cost of the improvements and their ability to be added later in construction, as funds are available.

Implementation was low for solar design, with no widespread photovoltaic pre-wiring and only 15.8 percent of respondents' jurisdictions always or mostly using passive solar design. Administrators may not understand the low cost of stringing extra wire and conduit for a photovoltaic system. In addition, they may not feel active solar technology is accessible to their clients and consider it a frivolous expense. While passive solar efforts were marginally higher, the respondents still did not meet the model standards. Passive solar requires more site specific evaluation, which many administrators may feel is too time-consuming.

For the entire category, new construction and reconstruction generally scored higher than rehabilitation[24]. This was expected, as it is generally more complex and expensive to retrofit energy efficiency in an existing house.

**Table 5.1: Energy Systems Response Summary**

| Ideal Type Sub-Categories | Questionnaire Item | Always & Mostly | Mode | Benchmark | Benchmark Assessment |
|---|---|---|---|---|---|
| Whole house energy efficiency certification | My jurisdiction constructs homes to be Energy Star certified. | 24.6% | Never | 75% | Not Met |
| Energy efficient lighting, fixtures and appliances | My jurisdiction installs Energy Star certified lighting and fixtures.<br><br>My jurisdiction installs Energy Star certified appliances. | 36.8%<br><br>56.2% | Sometimes<br><br>Always, Mostly, Sometimes | 80%<br><br>80% | Not Met<br><br>Not Met |
| Energy efficient heating, ventilation and air conditioning systems (HVAC) | My jurisdiction installs Energy Star certified HVAC systems. | 50.9% | Sometimes | 80% | Not Met |
| Tight construction | My jurisdiction requires use of and verification of tight construction, such as a blower-door test. | 5.3% | Never | 75% | Not Met |

[24] See Appendix A

| Ideal Type Sub-Categories | Questionnaire Item | Always & Mostly | Mode | Benchmark | Benchmark Assessment |
|---|---|---|---|---|---|
| Solar design | My jurisdiction pre-wires houses so that photovoltaic systems (solar energy) can be installed in the future. | 0.0% | Never | 80% | Not Met |
| | My jurisdiction uses passive solar design, such as maximizing sunlight for lighting and shading windows exposed to afternoon sun. | 15.8% | Never | 80% | Not Met |
| n = 36 | | | | | |

**Water Conservation**

Water conservation had similar results to energy systems and did not meet any benchmarks. **Table 5.2** summarizes the responses. Use of low or ultra-low flow water fixtures was somewhat common, with 61.4 percent of respondents reporting their jurisdictions always or mostly install them. Though it did not meet the benchmark, the modal response was always. Given the costs to install such fixtures, however, the percentage should have been higher. Low-flow fixtures often cost only a few dollars more than standard fixtures. Also, administrators may not realize they are installing low-flow fixtures if it is part of a set of standard bid specifications.

Not surprisingly, exterior water efficiency had a very low rate of implementation, with all respondents saying they never install rainwater-harvesting equipment. This may be considered an unnecessary expense, but can often be done for less than $100. Respondents may have thought all roof runoff was to be harvested, which would result in a much larger and more expensive system. Perhaps stating an amount harvested might have increased positive response.

**Table 5.2: Water Conservation Response Summary**

| Ideal Type Sub-Categories | Questionnaire Item | Always & Mostly | Mode | Benchmark | Benchmark Assessment |
|---|---|---|---|---|---|
| Water efficient fixtures | My jurisdiction installs low or ultra-low flow water fixtures in bathrooms and kitchens. | 61.4% | Always | 80% | Not Met |
| Exterior water efficiency | My jurisdiction installs rainwater harvesting systems. | 0.0% | Never | 80% | Not Met |
| n = 36 | | | | | |

### Indoor Air Quality

Indoor air quality responses did well for the allergens and mold subcategory, but lacked effort in addressing volatile organic compounds. For all subcategories except humidistat and timer switches on bathroom vents, several responses for each construction type indicated their jurisdictions always or mostly implemented the model, showing it is possible on a restricted budget. The responses regarding indoor air quality are described in **Table 5.3**.

The impact of government endorsement on several standards is visible. Most Texas cities follow the 2003 or newer International Residential Building Code, which mandates the ACCA manuals and proper ventilation in kitchens and bathrooms. Each of those questionnaire responses had more than 85 percent of jurisdictions always or mostly implementing, approaching universal adoption. Based on the modal response being always and exceeding the benchmark, research seems to indicate the jurisdictions met the model for those two questionnaire items. Energy Star bathroom vents were not as popular, with only 14 percent reporting their jurisdictions always or mostly installed them. Combined with the high results for venting in the kitchen and bathroom, this may indicate focus on the goal of providing ventilation rather than doing so in the most efficient way possible. In addition, Energy Star bathroom vents are a new technology that have not had the level of exposure Energy Star appliances and fixtures have. Low percentages reported for humidistats and timers on the vents may indicate lack of awareness or a feeling amongst jurisdictions that they are unnecessary. One might agree with them on the necessity if occupant education (discussed later) faired better in questionnaire responses.

Volatile Organic Compound (VOC) reduction did not receive widespread adoption among the respondents' jurisdictions. Percentages of those jurisdictions that always or mostly followed a standard were in the 15 to 22 percent range, with sealed non-vinyl floors fairing a slightly better 31.6 percent. Administrators may not be aware that compliant floor coverings and paint do not cost more than standard items. With sealed, non-vinyl floors, administrators may not realize products like natural linoleum often cost less than carpet while providing a healthy air quality. In addition, sealed floors are easier to clean and host fewer allergens. The low percentages for eliminating VOC and formaldehyde from construction materials may indicate administrators are unaware such products are available at comparable cost to standard.

**Table 5.3: Indoor Air Quality Response Summary**

| Ideal Type Sub-Categories | Questionnaire Item | Always & Mostly | Mode | Benchmark | Benchmark Assessment |
|---|---|---|---|---|---|
| Allergens and mold | My jurisdiction sizes and installs HVAC systems according to ACCA Manuals D, S and J. | 86.0% | Always | 80% | Met |
| | My jurisdiction installs vents in all kitchens and bathrooms, and vents them to the outside. | 87.8% | Always | 80% | Met |
| | My jurisdiction requires installation of Energy Star certified vents. | 14.0% | Never | 80% | Not Met |
| | My jurisdiction installs humidistat or timer switches on bathroom vents. | 0.0% | Never | 80% | Not Met |
| Volatile Organic Compounds | My jurisdiction installs floor coverings free from formaldehyde and other volatile organic compounds (VOC), such as Green Label certified. | 21.0% | Never | 80% | Not Met |
| | My jurisdiction installs sealed, non-vinyl floors, such as linoleum, ceramic tile, laminate, or cement rather than carpet. | 31.6% | Never | 80% | Not Met |
| | My jurisdiction uses low or no volatile organic compounds (VOC) in paint, such as those that are Green Seal certified. | 21.0% | Never | 80% | Not Met |
| | My jurisdiction requires all materials used in construction, such as composite woods, caulks, and adhesives, not contain formaldehyde or other volatile organic compounds (VOC). | 15.8% | Never | 80% | Not Met |
| n = 36 | | | | | |

**Site Selection, Design, and Landscape Ecology**

The Site selection, design, and landscape ecology category had some positive response, but like other categories, the jurisdictions generally failed to meet the model benchmarks. With the exception of water-permeable hardscapes, all questionnaire items had at least some respondents indicate they implemented that aspect of Green building mostly or always. Once again, this indicates Green building is possible on a restricted budget. Responses regarding site selection, design, and landscape ecology are summarized in **Table 5.4**.

The lone bright spot was the infill subcategory, which had slightly more than 84 percent of respondents indicate their jurisdictions always or mostly located their housing programs in established neighborhoods. Additionally, the modal response was always. Based on the results exceeding the benchmark, research seems to indicate the jurisdictions met the model for the questionnaire item. The frequency of adoption may result from most low-moderate income areas usually occurring in established neighborhoods.

Transit, service and employment proximity did not fair as well as might be expected, with none meeting the model benchmarks. The percentage always or mostly locating projects within ¼ mile of transit was less than 10 percent. This could be a result of some respondents not having mass transit available in their city. The survey results reported slightly better, but still unacceptable percentages (17.5 percent) for proximity to services and employment. Given the high response rate for infill, administrators may be unaware of what opportunities may be available in the established neighborhood. Despite that possibility, administrators do not seem to consider proximity when selecting project sites.

Stormwater management, and use of native or adaptive vegetation bore similar negative results. Revegetation only occurs always or mostly in 36.8 percent of programs according to the respondents. Some jurisdictions may make this the responsibility of the occupant as a form of sweat equity. Less than 10 percent of respondents always or mostly install water permeable hardscapes. Lack of implementation for permeable surfaces might be a result local codes that require concrete for driveways and sidewalks and do not specifically allow other less expensive materials like decomposed granite. Low positive responses (15.8 percent) for installing low water use landscaping may have a number of causes, such as landscaping being viewed as a luxury or that administrators simply do not consider ongoing maintenance when purchasing plants.

**Table 5.4: Site Selection, Design, and Landscape Ecology Response Summary**

| Ideal Type Sub-Categories | Questionnaire Item | Always & Mostly | Mode | Benchmark | Benchmark Assessment |
|---|---|---|---|---|---|
| Infill, brownfield and greyfield sites | My jurisdiction selects sites in established neighborhoods with existing infrastructure. | 84.2% | Always | 80% | Met |
| Proximity to transit, services and employment | My jurisdiction selects sites that are within ¼ mile of transit. | 8.8% | Never | 80% | Not Met |
| | My jurisdiction selects sites that are within ½ mile of at least four community services or retail facilities, such as a grocery store, day care or health clinic. | 17.5% | Sometimes | 80% | Not Met |
| Stormwater management | My jurisdiction revegetates the site following construction. | 36.8% | Never | 80% | Not Met |
| | My jurisdiction installs water-permeable surfaces on all hardscapes, such as using permeable cement for driveways and walkways. | 7.0% | Never | 80% | Not Met |

| Ideal Type Sub-Categories | Questionnaire Item | Always & Mostly | Mode | Benchmark | Benchmark Assessment |
|---|---|---|---|---|---|
| Native and adaptive vegetation | My jurisdiction requires that all landscaping be xeriscaping, or use native/adaptive plants. | 15.8% | Never | 80% | Not Met |
| n = 36 | | | | | |

**Building Ecology, Waste, and Recycling**

Overall, building ecology, waste and recycling had some of the worst rates of implementation among those surveyed. With the exception of a construction waste plan, alternative building methods and use of preassembled components, at least some respondents indicated their jurisdictions always or mostly included the items in their construction methods. **Table 5.5** summarizes the results for the building ecology, waste and recycling category.

Site recycling experienced low levels of adoption, with respondents indicating less than seven percent of their jurisdictions always or mostly adhered. Jurisdictions may feel deconstruction is too time-consuming. In addition, they may lack access to a facility capable of handling the salvage and recycling materials. For similar reasons, the jurisdictions may not have a construction waste management plan.

Reducing use of raw material fared slightly better. Rehabilitating and building houses smaller than the national average was more common, with 79 percent of respondents reporting their jurisdictions always or mostly build houses smaller than 1,890 square feet. With a modal response of mostly and proximity to the 80 percent benchmark, the research indicates the programs met the benchmark. Slightly concerning, however, is the somewhat lower levels of adoption for new construction[25]. Building smaller houses seems sensible as the financial restrictions of the grant programs likely prevent jurisdictions from building larger, market-standard houses. While still failing to meet the benchmark, responses showed some preference (55.1 percent always or mostly) for rehabilitation, which could be considered the ultimate form of building recycling. Nearly one-third of respondents indicated their programs always or mostly used recycled content materials—well below the benchmark but indicative of some significant adoption. Recycled content materials were more common for reconstruction and new construction, but less for rehabilitation[26]. The larger scopes of reconstruction and new construction may be better suited for using these types of materials. Some materials, like fiber cement siding, might be commonly appropriate for rehabilitation as it is resistant to rot and fire.

Use of materials certified as coming from fast-growth forests was uncommon among respondents' jurisdictions, with 8.8 percent always or mostly adhering to the model. Administrators may not be aware of certifications, such as the Forest Stewardship Council, and not included them in construction specifications. Nevertheless, some jurisdictions reported they mostly or always use certified materials, so it is within reach. Preassembled structural components were rare in the respondents' jurisdictions, with only 1.8 percent responding always or mostly. The nature of rehabilitation may make preassembled components impractical, but they should be used for the other types that do not require retrofitting. Perhaps the small size of the houses makes items like roof truss systems seem like over-engineering. Alternative building methods proved similarly unpopular, with none of the jurisdictions using the techniques always or mostly. While administrators may not be aware of such technologies, lack of contractor expertise may play a significant role.

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[25] See Appendix A
[26] See Appendix A

**Table 5.5: Building Ecology, Waste, and Recycling Response Summary**

| Ideal Type Sub-Categories | Questionnaire Item | Always & Mostly | Mode | Benchmark | Benchmark Assessment |
|---|---|---|---|---|---|
| Site recycling | My jurisdiction deconstructs homes rather than demolishes, and salvages, recycles or reuses the materials when possible. | 7.0% | Never | 80% | Not Met |
| | My jurisdiction requires a construction waste management plan that mandates at least 50% of construction and site waste be recycled or salvaged. | 1.8% | Never | 80% | Not Met |

| Ideal Type Sub-Categories | Questionnaire Item | Always & Mostly | Mode | Benchmark | Benchmark Assessment |
|---|---|---|---|---|---|
| Reducing use of raw material | My jurisdiction builds or rehabilitates housing units that are only less than 1,890 square feet. | 79.0% | Mostly | 80% | Met |
| | My jurisdiction favors rehabilitation of existing housing units over constructing new units. | 54.1% | Mostly | 80% | Not Met |
| | My jurisdiction uses recycled or reconstituted content materials when available, such as engineered wood and fiber cement siding. | 33.3% | Sometimes | 80% | Not Met |
| | My jurisdiction uses wood materials certified as coming from fast-growth forests or remilled salvage wood, such as through the Forest Stewardship Council. | 8.8% | Never | 80% | Not Met |
| | My jurisdiction uses preassembled structural components, such as manufactured roof trusses and preassembled walls. | 1.8% | Never | 80% | Not Met |
| | My jurisdiction uses alternative building methods, such as structurally insulated panels (SIP), Optimal Value Engineering (OVE) and Insulated Concrete Forms (ICF). | 0.0% | Never | 80% | Not Met |
| n = 36 | | | | | |

**Integrated Design**

The integrated design category proved troubling; none of the results indicated Texas jurisdictions met the benchmarks for the model. **Table 5.6** summarizes the integrated design responses. According to respondents, many jurisdictions do not involve a multidisciplinary team. In most cases, they likely have staff in other departments that they could consult. Lack of multidisciplinary involvement is a recipe for change orders during construction.

In addition, less than two percent of respondents indicated their jurisdictions always or mostly had and used a written plan to encourage Green building practices. This may be because administrators are not required to create such a plan and given other workloads, do not have the interest. Such a plan does not cost nor commit a jurisdiction to anything, only to considering Green methods. Similarly low percentages were reported for conducting an analysis of each housing unit to assess feasible Green building opportunities and using life cycle analysis when selecting materials. Again, this may result from administrative staffs stretched too thin or lack of expertise.

**Table 5.6: Integrated Design Response Summary**

| Ideal Type Sub-Categories | Questionnaire Item | Always & Mostly | Mode | Benchmark | Benchmark Assessment |
|---|---|---|---|---|---|
| Interdisciplinary involvement | My jurisdiction consults a multi-discipline team in designing new housing units and rehabilitation, such as architects, mechanical systems professionals and planners. | 31.6% | Never | 80% | Not Met |

| Ideal Type Sub-Categories | Questionnaire Item | Always & Mostly | Mode | Benchmark | Benchmark Assessment |
|---|---|---|---|---|---|
| Whole-systems approach | My jurisdiction has and uses a written plan to encourage Green building practices in new construction and rehabilitation. | 1.8% | Never | 80% | Not Met |
| | My jurisdiction conducts an analysis of each housing unit for rehabilitation to assess which Green building methods are cost-effective. | 1.8% | Never | 80% | Not Met |
| | When information is available, my jurisdiction uses life-cycle analysis of environmental impacts to select materials. | 1.8% | Never | 80% | Not Met |
| n = 36 | | | | | |

**Owner and Occupant Education**

Owner and Occupant Education had slightly better results than integrated design, but still did not meet any benchmarks. Responses for the owner and occupant education category are summarized in **Table 5.7**. For the most part, respondents indicated their jurisdictions provided training to occupants, with 63.1 percent always or mostly following the standard. It seems, however, this should be nearly universal, as the occupants would likely press administrators to show them how any new features in the residence operate. The level of training falls off to 21 percent for providing written information. If jurisdictions frequently use the same materials and items, then it seems like this could be provided without substantial difficulty. Some improvement was seen with native languages for training occupants (38.6 percent always or mostly). Language is often a barrier for low-moderate income occupants, so providing information in the format they are most comfortable in helps ensure understanding.

Green housekeeping efforts may have been the most disappointing of the entire Green building model, because they could be standard references. The percentage of respondents' jurisdictions always or mostly providing information on cleaning the housing unit in an environmentally friendly manner was only 14 percent. Administrators may not have considered the benefits of such advice, which can include savings for occupants in addition to creating a Greener housing unit. Also, most jurisdictions did not widely distribute information on other methods the occupants can live in an environmentally friendly manner, with less than a quarter of respondents reporting they always or mostly take such action. Much of this information is likely already available from local utility providers.

**Table 5.7: Owner and Occupant Education Response Summary**

| Ideal Type Sub-Categories | Questionnaire Item | Always & Mostly | Mode | Benchmark | Benchmark Assessment |
|---|---|---|---|---|---|
| Use of systems and features | My jurisdiction conducts a training session with the housing unit occupants to explain how all home features work. | 63.1% | Always | 80% | Not Met |
| | My jurisdiction provides a written guide to the housing unit that explains how all home features work. | 21.0% | Never | 80% | Not Met |
| Native language | My jurisdiction provides training sessions and guides in the occupants' native language. | 38.6% | Sometimes | 80% | Not Met |

| Ideal Type Sub-Categories | Questionnaire Item | Always & Mostly | Mode | Benchmark | Benchmark Assessment |
|---|---|---|---|---|---|
| Green housekeeping | My jurisdiction provides the occupants information on environmentally responsible ways of cleaning the housing unit. | 14.0% | Never | 80% | Not Met |
| | My jurisdiction provides information on other methods the occupants can implement that achieve environmental goals, such as area recycling programs, renewable energy providers and proper handling of hazardous materials. | 19.3% | Sometimes | 80% | Not Met |
| n = 36 | | | | | |

These results provide a number of findings relevant to the research purpose. Findings and recommendations are discussed in the next chapter.

# Chapter 6: Conclusions

This chapter presents the overall results of this study and its implications, including an assessment of Texas Community Development Block Grant (CDBG) and HOME Investment Partnership (HOME) local recipients as they compare to the ideal model as indicated in this research. The final chapter also makes recommendations for future action and scholarly research. Recommendations are based on the research findings.

While the program administrators are not Green building experts, nor should they be required as such, they conduct their programs with professionalism and an open attitude toward improvement. They are good at what they do, but they cannot focus exclusively on housing. Many programs suffer from low staffing levels and are pulled between projects ranging from public infrastructure improvements to assisting in creating a community health clinic in a low income neighborhood. Local program administrators do have allies at the Federal government for improving their housing projects, as Housing and Urban Development staff is supportive of efforts to improve the quality and efficiency of affordable housing.

## Summary of Findings

The research was intended to gauge how well local Texas recipients of CDBG and HOME funds' housing programs met the ideal affordable Green building model. The results of the research seem to indicate that a majority of criteria in the model do not appear in the local housing programs. None of the results clearly met the benchmarks, with only four coming close enough to be considered partially meeting. **Table 6.1** reflects on how each of the seven main descriptive categories rated.

**Table 6.1: Summary of Findings**

| Ideal Type Categories | Adherence to Model | Strengths | Weaknesses |
|---|---|---|---|
| **Energy Systems**<br>▪ Whole house energy efficiency certification<br>▪ Energy efficient lighting, fixtures and appliances<br>▪ Energy efficient heating, ventilation and air conditioning systems (HVAC)<br>▪ Tight construction<br>▪ Solar design | None of the seven questionnaire response results met the benchmarks | ▪ Jurisdictions are aware of Energy Star program and have implemented on smaller items and HVAC | ▪ Adoption of full Energy Star certification for housing units is low.<br>▪ Some lack of understanding of Energy Star details.<br>▪ For the most part, solar design is not a consideration. |
| **Water Conservation**<br>▪ Water efficient fixtures<br>▪ Exterior water efficiency | None of the two questionnaire response results met the benchmarks | ▪ Indoor water conservation is fairly common. | ▪ With the negligible cost of low-flow fixtures, indoor water conservation should be universally adopted.<br>▪ Exterior water efficiency is not a consideration. |
| **Indoor Air Quality**<br>▪ Allergens and mold<br>▪ Volatile Organic Compounds | Two of the eight questionnaire response results met the benchmarks | ▪ Adoption of proper HVAC design is widespread and almost universal.<br>▪ Housing units constructed have properly vented kitchens and bathrooms, two areas particularly susceptible to poor air quality. | ▪ Jurisdictions have not made the connection between efficiency and ventilation.<br>▪ Jurisdictions could make occupants more apt to use vents by installing timers. Otherwise, they may never be used.<br>▪ Jurisdictions do not adequately consider the impact of volatile organic compounds when selecting materials, particularly coverings and paint. |
| **Site Selection, Site Design, and Landscape Ecology**<br>▪ Infill, brownfield and greyfield sites<br>▪ Proximity to transit, services and employment<br>▪ Stormwater management<br>▪ Native and adaptive vegetation | One of the six questionnaire response results met the benchmarks | ▪ Jurisdictions understand the benefit to infill development and apply it to their housing programs. | ▪ Proximity to transit, services and employment is not a consideration.<br>▪ Stormwater management is not a consideration.<br>▪ Using native and adoptive vegetation is the exception rather than the norm. |

| Ideal Type Categories | Adherence to Model | Strengths | Weaknesses |
|---|---|---|---|
| **Building Ecology, Waste, and Recycling**<br>▪ Site recycling<br>▪ Reducing use of raw material | One of the eight questionnaire response results met the benchmarks | ▪ Recipients appear to favor rehabilitation over reconstruction or new construction.<br>▪ Jurisdictions avoid constructing oversized housing units.<br>▪ Recipients have used some recycled materials during construction. | ▪ Recipients do not use recycled materials during construction frequently.<br>▪ There is no waste management to speak of, particularly recycling and salvage.<br>▪ Recipients do not consider sustainable forestry in wood selection.<br>▪ Jurisdictions to not adequately use alternative building methods that reduce raw material consumption. |
| **Integrated Design**<br>▪ Interdisciplinary involvement<br>▪ Whole-systems approach | None of the four questionnaire response results met the benchmarks | ▪ None | ▪ There is no interdisciplinary involvement in the project design.<br>▪ There is no holistic approach to the design process.<br>▪ There are no guiding documents in place to consider Green features on a case-by-case basis.<br>▪ Jurisdictions do not consider the environment when selecting materials. |
| **Owner and Occupant Education**<br>▪ Use of systems and features<br>▪ Native language<br>▪ Green housekeeping | None of the five questionnaire response results met the benchmarks | ▪ Jurisdictions do usually provide some training to occupants on home features.<br>▪ Jurisdictions often use native language to provide training | ▪ Written training documents are rare.<br>▪ Training should be universal.<br>▪ Native language should be universal.<br>▪ No information is provided on cleaning units in an environmentally responsible way.<br>▪ No information is provided on other methods to live Green, like area recycling programs. |

**Recommendations**

On the whole, local jurisdictions' housing programs do not align with the affordable Green building model. Even though only four questionnaire items partially met the benchmarks, bringing housing programs into compliance is simpler than the data indicates. Due to the interconnected nature of the Green categories, each recommendation may serve to address several shortcomings in different categories.

In general, many of the clients participating in local housing programs are in such poor living conditions that administrators may view anything done to improve the living environment as meeting their objectives. Therefore, administrators may view Green construction efforts as extravagant given current living standards and community needs. Administrators may tend to view housing programs in a short time frame rather than looking at the impacts on clients several years removed from the construction. Shifting thought toward long-range benefits is essential for any Green building program to gain a foothold.

Recommendation 1: Make a Plan and Execute It

Each jurisdiction has different needs as evidenced by the wide range of responses. Therefore, each jurisdiction needs to assess itself to determine what efforts apply to them. Some of the lowest scores reported in the research had to do with a lack of planning or consideration of alternatives. Planning, by its nature, involves consultation with multiple disciplines, which would address integrated design at its most elementary stage. For example, a jurisdiction may find in community research that there is not a construction waste recycling center in their area. As a result, they may implement cutting plans as an alternate or change construction materials altogether. Likewise, programs in West Texas may find straw-bale construction a feasible alternative, while those in East Texas along the coast may select structurally insulated panels (SIP) for their strength. In each case raw material usage is reduced, but with entirely different systems.

Within a Green-building action plan, jurisdictions can create templates and checklists for evaluating each project. For example, they can routinely choose to eliminate west and north windows on a housing unit in an effort to improve solar design. In addition, the plan can narrow which products and processes are feasible and available for the region. If something is not available, such as a contractor experienced in energy efficiency certification, then the plan's implementation schedule can recommend such action. In short, a Green-building action plan is appropriate for every jurisdiction, no matter what stage of Green building execution they have achieved. Such a plan addresses many of the weaknesses in material feasibility, waste and site management, gaining multidisciplinary involvement, and taking a holistic approach to program design. In planning, many jurisdictions may be surprised by what their programs are capable of.

Recommendation 2: Experiment Through Bid Processes

Given the regulatory environments of federal grant programs, particularly in bidding and procurement, many jurisdictions may have hesitation to require such standards for fear they will not receive bids for work or the bids will be too expensive. From the author's own experience, bid alternates provide an excellent way to test the waters of Green building.

The HOME Owner Occupied Assistance program for San Marcos, Texas in 2007 was restricted to expending no more than $60,000 on any single housing unit. Based on escalating construction prices in the region, program administrators were concerned that adding too many Green requirements might exceed the maximum budget and force the procurement process to restart with amended specifications. To avoid the situation, they set several bid alternates for varying levels of Energy Star construction, including whole house certification, Energy Star appliances, Energy Star lighting, and Energy Star HVAC systems. In addition, the construction specifications were modified to permit use of alternative building methods, such as structurally insulated panels. As expected, the bids were higher than previous years. Fortunately, including bid alternatives allowed half of the housing units to be built as certified Energy Star homes.

The best part of many Green building methods suggested in the model is they do not require intimate technical knowledge for program administrators. Several items reference a third-party verifier. For example, the Carpet and Rug Institute have the Green Label program certifying the carpet does not contain volatile organic compounds. Likewise, the Forest Stewardship Council certifies sustainable wood products so program administrators are not responsible for researching origins. Perhaps the most recognizable of the third-party verifiers is the Energy Star program.

Recommendation 3: The Best Things in Green are Free

As reflected in the literature review, many people assume Green building means spending more money. This is not the case. Indoor air quality, in particular, has many methods available that require no additional cost—merely small changes to construction specifications. In addition, some of the Green building methods can reduce costs. Some free and ultra-low cost methods recommended for standardization include:

- ❒ Require low or no volatile organic compounds in paint.
- ❒ Require low or no volatile organic compounds in carpet.
- ❒ Require low or no volatile organic compounds in construction materials, such as caulks and engineered wood products (i.e. particle board and oriented-strand board).
- ❒ Require sealed, no volatile organic compound floors. Natural linoleum in particular can reduce costs.

- ❐ Require low or ultra-low flow water fixtures. In many cases, flow reducing aerators cost only a few dollars and may be available for free from utility providers.
- ❐ Require native/adaptive plants for all landscaping.
- ❐ Using water-permeable surfaces for hardscape elements like driveways and sidewalks. Though permeable concrete can cost more, other materials cost less than traditional concrete like decomposed/crushed granite. Crushed glass is also a suitable surface and earns points for using a recycled product.
- ❐ Require use of some reconstituted or recycled materials when it costs less than standard products. Fiber-cement siding is an excellent example as it often costs less than wood siding and has the added benefits of flame resistance, improved durability, and being a more environmentally product.
- ❐ Require all lighting and appliances be Energy Star. At this point, the cost differences between standard and Energy Star products are negligible. As reported earlier, Energy Star is quickly becoming a de facto energy code for community development corporations.

Recommendation 4: Tap Jurisdiction Resources

Grant recipients do not necessarily need to hire Green building consultants or go outside the jurisdiction to find assistance. Utility departments can be an excellent resource for information and, in some cases, products for use in the housing program. This is particularly true of information useful in a standard reference library, discussed later.

San Marcos' housing program once again provides an example for using all resources available. San Marcos has an active water conservation program, which offers a variety programs like rebates for efficient appliances, low-cost dual-flush toilets and free low-flow aerators. Through cooperation between the housing and toilet programs, the 2007 program homes received dual-flush toilets at no cost to the housing program. In addition, a housing designer serving on the City Council specialized in small, efficient home design and contributed her expertise to the home reconstruction plans.

In addition, building departments can provide useful expertise for all housing program construction issues. Other jurisdiction departments, such as a department that manages public facilities like city hall, can be useful for determining how effective energy conservation efforts are.

Recommendation 5: Build a Standard Reference Library

One of the greater disappointments of the survey results was the lack of training and materials for housing program clients. Green building features are useless if occupants to not use or maintain them properly. In most programs, many of the home features should be identical from house to house, often a result of bulk purchasing and concurrent construction. Once a Green-building action plan is in place, a jurisdiction should be able to estimate whether some items will be included in some or all houses. Each Green item could have a training document that could be included in a manual given to occupants. For many jurisdictions, this might simply be a matter of keeping a checklist of Green features for each housing unit a printing the appropriate guides.

The National Association of Home Builders (2006, 149) suggests including the following information in the manual and training:

- ❒ Narrative detailing importance of operations and maintenance to keep home green;

- ❒ Any Green certificates;
- ❒ Warranty and instructions for equipment and appliances;
- ❒ Household recycling opportunities;
- ❒ Information to purchase energy from renewable provider;
- ❒ Benefits of compact fluorescent light bulbs;
- ❒ List of habits and actions to optimize water and energy use;
- ❒ Local transportation options;
- ❒ Clear labeling of safety valves and controls;
- ❒ Green items included in the home;
- ❒ Maintenance Checklist;
- ❒ Proper handling and disposal of hazardous materials; and
- ❒ Information on organic pesticides, fertilizers, environmental cleaning products

Green housekeeping provides one of the best opportunities for a generic guide to all housing program clients, as well as ensure a Green house continues to operate in a Green manner once the housing program is finished.

Recommendation 6: Federal Encouragement

The Federal government has already implied support for Green building in affordable housing through the Energy Star program and its relationship to the Community Development Block Grant and HOME Investment Partnership grants. Recently, the Department of Housing and Urban Development established performance measures for the grants, which include energy efficiency. The Federal government could take this a step further with establishment of a simple

Green building standard, such as the model supported through this research. Any Federal performance standard, however, should refrain from making this an unfunded directive.

Many grant recipients struggle to maintain housing programs as their funding amounts have reduced over the past several years. Therefore, local program administrators are unlikely to enact Green measures without financial backing. The Federal government should consider establishing a performance bonus for assisted housing programs to cover the increased costs to meet the affordable Green building model. As shown in the literature, such a bonus need only increase funding by approximately five percent to permit housing programs to provide clients an improved quality of life and reduce environmental impact.

**Next Steps for Research**

Scholarly work need not end with the affordable Green building model and investigation of Texas grant recipients presented in this research. There are several opportunities to expand on the knowledge gained regarding Green building in the affordable housing context.

While a model was developed and jurisdictions assessed for adherence, this research did not investigate the reasons for the responses. For example, future research may investigate why jurisdictions do not implement a particular aspect of the Green building model. In addition, future research could reveal trends in Green building under these housing programs. Data collected for this survey included responding jurisdiction names. The names would allow researchers to investigate the impact of funding amounts and staffing levels on implementation of Green building methods.

In addition, jurisdictional adoption of the methods advocated in the affordable Green building model may vary geographically. Future research may investigate whether local jurisdictions in other states and regions follow the affordable Green building model. Similarly, the findings from this research could become new benchmarks to assess whether housing programs have increased adoption of Green building methods after a few years. Finally, a researcher might choose to develop some of the standard references suggested as recommendations in this research. Such a reference might include a Green-building action plan template, or pamphlets on Green living for occupants. Finally, a researcher might choose to conduct a detailed cost-benefit analysis of Green building in affordable housing to help establish tangible financial ramifications of such a program. Such research, however, must be careful to consider the financial impacts for the client beyond simple utility savings and consider quality of life issues like respiratory health.

**In Closing**

Green building should not be restricted to the realm of the wealthy. Green construction and affordable housing seem to complement each other, as Green building can drastically improve the lives of low-moderate income residents. Residents' lives improve through utility savings and indirect quality of life benefits, such as improved health and better access to economic opportunity. While the data shows Texas local grant recipients do not meet the model presented, by implementing the recommendations explained above they can come closer to adherence.

With the model developed through this research, local government can play an instrumental role in lifting blighted low-income neighborhoods and showing the private sector Green building is possible for all socio-economic levels. Though the model may need additional refinement, it might serve as a template for establishing national Green building standards for federally assisted affordable housing.

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## Attachment A: Survey Instrument and Results

Administrators were asked a series of questions in an online survey. Following is each survey question in similar format to the survey with the actual response count. Two free response questions, regarding jurisdiction name and contact information, are omitted from the material.

**Green Building and Affordable Housing in Texas**

The information entered in this section will help you avoid questions later in the survey that do not apply to your jurisdiction. Also, it will also provide information useful for future researchers.

The following survey examines the degree to which housing rehabilitation, reconstruction and new construction under the CDBG and HOME programs have implemented Green building measures. For the purposes of this research, the following basic definitions apply:

Rehabilitation: renovating an existing residential structure

Reconstruction: demolishing an existing structure and replacing it with a new structure on the same site

New Construction: constructing a new structure on a new property

In many jurisdictions, subrecipients or Community Housing Development Organizations (CHDO) may perform housing duties on its behalf. If this is the case in your jurisdiction, please answer to the best of your knowledge.

1. **Jurisdiction Name:** <omitted>

2. **My Jurisdiction is a:**

| n | |
|---|---|
| 35 | Community Development Block Grant (CDBG) Entitlement |
| 19 | HOME Investment Partnership (HOME) Participating Jurisdiction |

3. **My jurisdiction's housing construction program funded through CDBG entitlement and/or HOME entitlement includes: (check all that apply)**

| n | |
|---|---|
| 28 | Rehabilitation |
| 16 | Reconstruction |
| 13 | New Construction |
| 2 | None of These |

4. **My jurisdiction constructs homes to be Energy Star certified.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 1 | 3 | 5 | 7 | 12 |
| Reconstruction | 16 | 2 | 2 | 2 | 2 | 8 |
| New Construction | 13 | 2 | 4 | 3 | 2 | 2 |

**5. My jurisdiction installs Energy Star certified lighting and fixtures.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 3 | 5 | 12 | 3 | 5 |
| Reconstruction | 16 | 4 | 3 | 6 | 0 | 3 |
| New Construction | 13 | 3 | 3 | 6 | 0 | 1 |

**6. My jurisdiction installs Energy Star certified appliances.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 4 | 7 | 9 | 3 | 5 |
| Reconstruction | 16 | 6 | 4 | 5 | 0 | 1 |
| New Construction | 13 | 6 | 5 | 2 | 0 | 0 |

**7. My jurisdiction installs Energy Star certified HVAC systems.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 6 | 5 | 8 | 4 | 5 |
| Reconstruction | 16 | 4 | 4 | 4 | 2 | 2 |
| New Construction | 13 | 4 | 4 | 4 | 0 | 1 |

**8. My jurisdiction requires use of and verification of tight construction, such as a blower-door test.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 1 | 0 | 1 | 4 | 22 |
| Reconstruction | 16 | 1 | 0 | 2 | 1 | 12 |
| New Construction | 13 | 1 | 0 | 4 | 2 | 6 |

**9. My jurisdiction pre-wires houses so that photovoltaic systems (solar energy) can be installed in the future.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 0 | 0 | 0 | 0 | 28 |
| Reconstruction | 16 | 0 | 0 | 0 | 0 | 16 |
| New Construction | 13 | 0 | 0 | 0 | 1 | 12 |

**10. My jurisdiction uses passive solar design, such as optimizing sunlight for lighting and shading windows exposed to afternoon sun.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 1 | 0 | 2 | 5 | 20 |
| Reconstruction | 16 | 3 | 1 | 3 | 1 | 8 |
| New Construction | 13 | 2 | 2 | 2 | 2 | 5 |

**11. My jurisdiction installs low or ultra-low flow water fixtures in bathrooms and kitchens.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 8 | 8 | 4 | 3 | 5 |
| Reconstruction | 16 | 6 | 5 | 2 | 2 | 1 |
| New Construction | 13 | 4 | 4 | 3 | 1 | 1 |

**12. My jurisdiction installs rainwater harvesting systems.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 0 | 0 | 0 | 0 | 28 |
| Reconstruction | 16 | 0 | 0 | 0 | 0 | 16 |
| New Construction | 13 | 0 | 0 | 0 | 0 | 13 |

**13. My jurisdiction sizes and installs HVAC systems according to ACCA Manuals D, S and J. This is required to meet the 2003 International Residential Building Code, which may be a more common reference in your jurisdiction.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 19 | 4 | 3 | 0 | 2 |
| Reconstruction | 16 | 15 | 0 | 1 | 0 | 0 |
| New Construction | 13 | 10 | 1 | 2 | 0 | 0 |

**14. My jurisdiction installs vents in all kitchens and bathrooms, and vents them to the outside.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 15 | 7 | 2 | 1 | 3 |
| Reconstruction | 16 | 12 | 3 | 1 | 0 | 0 |
| New Construction | 13 | 11 | 2 | 0 | 0 | 0 |

**15. My jurisdiction requires installation of Energy Star certified vents.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 1 | 2 | 4 | 3 | 18 |
| Reconstruction | 16 | 0 | 2 | 1 | 1 | 12 |
| New Construction | 13 | 1 | 2 | 2 | 2 | 6 |

**16. My jurisdiction installs humidistat or timer switches on bathroom vents.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 0 | 0 | 0 | 4 | 24 |
| Reconstruction | 16 | 0 | 0 | 0 | 2 | 14 |
| New Construction | 13 | 0 | 0 | 3 | 3 | 7 |

**17. My jurisdiction installs floor coverings free from formaldehyde and other volatile organic compounds (VOC), such as Green Label certified.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 2 | 3 | 5 | 6 | 12 |
| Reconstruction | 16 | 3 | 2 | 1 | 3 | 7 |
| New Construction | 13 | 1 | 1 | 3 | 4 | 4 |

**18. My jurisdiction installs sealed, non-vinyl floors, such as linoleum, ceramic tile, laminate, or finished concrete rather than carpet.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 2 | 6 | 5 | 6 | 10 |
| Reconstruction | 16 | 1 | 5 | 1 | 3 | 6 |
| New Construction | 13 | 1 | 3 | 3 | 4 | 2 |

**19. My jurisdiction uses low or no volatile organic compounds (VOC) paint, such as those that are Green Seal certified.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 4 | 3 | 5 | 7 | 9 |
| Reconstruction | 16 | 2 | 2 | 1 | 5 | 6 |
| New Construction | 13 | 0 | 1 | 3 | 5 | 4 |

**20. My jurisdiction requires all materials used in construction, such as composite woods, caulks, and adhesives, not contain formaldehyde or other volatile organic compounds (VOC).**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 3 | 2 | 2 | 6 | 15 |
| Reconstruction | 16 | 2 | 1 | 0 | 4 | 9 |
| New Construction | 13 | 1 | 0 | 0 | 5 | 7 |

**21. My jurisdiction selects sites in established neighborhoods with existing infrastructure.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 20 | 4 | 3 | 0 | 1 |
| Reconstruction | 16 | 12 | 2 | 2 | 0 | 0 |
| New Construction | 13 | 5 | 5 | 3 | 0 | 0 |

**22. My jurisdiction selects sites that are within ¼ mile of transit.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 0 | 1 | 7 | 1 | 19 |
| Reconstruction | 16 | 1 | 1 | 5 | 0 | 9 |
| New Construction | 13 | 0 | 2 | 5 | 0 | 6 |

**23. My jurisdiction selects sites that are within ½ mile of at least four community services or retail facilities, such as a grocer store, day care or health clinic.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 0 | 3 | 11 | 3 | 11 |
| Reconstruction | 16 | 0 | 3 | 7 | 1 | 5 |
| New Construction | 13 | 0 | 4 | 7 | 0 | 2 |

**24. My jurisdiction revegetates the site following construction.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 5 | 2 | 4 | 4 | 13 |
| Reconstruction | 16 | 5 | 1 | 0 | 2 | 8 |
| New Construction | 13 | 5 | 3 | 1 | 1 | 3 |

**25. My jurisdiction installs water-permeable surfaces on all hardscapes, such as using permeable concrete for driveways and walkways.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 1 | 1 | 3 | 2 | 21 |
| Reconstruction | 16 | 0 | 0 | 2 | 2 | 12 |
| New Construction | 13 | 1 | 1 | 0 | 2 | 9 |

**26. My jurisdiction requires that all landscaping be xeriscaping, or use native/adaptive plants.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 3 | 1 | 2 | 2 | 20 |
| Reconstruction | 16 | 2 | 1 | 1 | 1 | 11 |
| New Construction | 13 | 1 | 1 | 1 | 2 | 8 |

**27. My jurisdiction deconstructs homes rather than demolishes, and salvages, recycles or reuses the materials when possible.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 0 | 2 | 4 | 4 | 18 |
| Reconstruction | 16 | 0 | 1 | 3 | 0 | 12 |
| New Construction | 13 | 0 | 1 | 0 | 0 | 12 |

**28. My jurisdiction has or requires a construction waste management plan that mandates at least 50% of construction and site waste be recycled or salvaged.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 0 | 1 | 0 | 1 | 26 |
| Reconstruction | 16 | 0 | 0 | 0 | 1 | 15 |
| New Construction | 13 | 0 | 0 | 0 | 0 | 13 |

**29. My jurisdiction builds or rehabilitates housing units that are less than 1,890 square feet.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 5 | 17 | 4 | 1 | 1 |
| Reconstruction | 16 | 12 | 2 | 0 | 2 | 0 |
| New Construction | 13 | 5 | 4 | 0 | 1 | 3 |

**30. My jurisdiction favors rehabilitation of existing housing units over constructing new units.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| | 29 | 7 | 9 | 5 | 7 | 1 |

**31. My jurisdiction uses recycled or reconstituted content materials when available, such as engineered wood and fiber cement siding.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 2 | 4 | 14 | 3 | 5 |
| Reconstruction | 16 | 5 | 4 | 4 | 1 | 2 |
| New Construction | 13 | 3 | 1 | 7 | 1 | 1 |

**32. My jurisdiction uses wood materials certified as coming from fast-growth forests or remilled salvage wood, such as through the Forest Stewardship Council.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 1 | 1 | 7 | 4 | 15 |
| Reconstruction | 16 | 2 | 1 | 4 | 1 | 8 |
| New Construction | 13 | 0 | 0 | 4 | 2 | 7 |

**33. My jurisdiction uses preassembled structural components, such as manufactured roof trusses and preassembled walls.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 0 | 0 | 5 | 7 | 16 |
| Reconstruction | 16 | 0 | 0 | 5 | 5 | 6 |
| New Construction | 13 | 0 | 1 | 7 | 3 | 2 |

**34. My jurisdiction uses alternative building methods, such as structurally insulated panels (SIP), Optimal Value Engineering (OVE) and Insulated Concrete Forms (ICF).**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 0 | 0 | 3 | 8 | 17 |
| Reconstruction | 16 | 0 | 0 | 4 | 3 | 9 |
| New Construction | 13 | 0 | 0 | 3 | 5 | 5 |

**35. My jurisdiction consults a multi-discipline team in designing new housing units and rehabilitation, such as architects, mechanical systems professionals and planners.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 3 | 1 | 8 | 1 | 15 |
| Reconstruction | 16 | 2 | 4 | 4 | 0 | 6 |
| New Construction | 13 | 2 | 6 | 2 | 1 | 2 |

**36. My jurisdiction has and uses a written plan to encourage Green building practices in new construction and rehabilitation.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 0 | 0 | 3 | 3 | 22 |
| Reconstruction | 16 | 1 | 0 | 3 | 1 | 11 |
| New Construction | 13 | 0 | 0 | 3 | 2 | 8 |

**37. My jurisdiction conducts an analysis of each perspective housing unit to assess which Green building methods are cost-effective.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 0 | 0 | 2 | 7 | 19 |
| Reconstruction | 16 | 1 | 0 | 3 | 2 | 10 |
| New Construction | 13 | 0 | 0 | 3 | 3 | 7 |

**38. When information is available, my jurisdiction uses life-cycle analysis of environmental impacts to select materials.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 0 | 0 | 2 | 7 | 19 |
| Reconstruction | 16 | 1 | 0 | 2 | 3 | 10 |
| New Construction | 13 | 0 | 0 | 1 | 5 | 7 |

**39. My jurisdiction conducts a training session with the housing unit occupants to explain how all home features work.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 8 | 8 | 3 | 4 | 5 |
| Reconstruction | 16 | 7 | 4 | 2 | 1 | 2 |
| New Construction | 13 | 4 | 5 | 2 | 1 | 1 |

**40. My jurisdiction provides a written guide to the housing unit that explains how all home features work.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 2 | 3 | 6 | 3 | 14 |
| Reconstruction | 16 | 4 | 1 | 2 | 0 | 9 |
| New Construction | 13 | 2 | 0 | 4 | 0 | 7 |

**41. My jurisdiction provides training sessions and guides in the occupants' native language.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 5 | 4 | 7 | 5 | 7 |
| Reconstruction | 16 | 6 | 2 | 6 | 0 | 2 |
| New Construction | 13 | 3 | 2 | 5 | 2 | 1 |

**42. My jurisdiction provides the occupants information on environmentally responsible ways of cleaning the housing unit.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 1 | 2 | 1 | 6 | 18 |
| Reconstruction | 16 | 2 | 1 | 1 | 3 | 9 |
| New Construction | 13 | 1 | 1 | 1 | 3 | 7 |

**43. My jurisdiction provides information on other methods the occupants can implement that achieve environmental goals, such as area recycling programs, renewable energy providers and proper handling of hazardous materials.**

| | n | Always | Mostly | Sometimes | Rarely | Never |
|---|---|---|---|---|---|---|
| Rehabilitation | 28 | 3 | 2 | 6 | 5 | 12 |
| Reconstruction | 16 | 3 | 1 | 4 | 1 | 7 |
| New Construction | 13 | 1 | 1 | 5 | 2 | 4 |

**Please provide your contact information if you or your jurisdiction wish to receive a summary of the findings and recommendations.**

<omitted>