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Comparison of Thirty Green Building Projects across the US: Common Elements

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Abstract

This study examined the green elements used in sixteen (16) single-family homes and fourteen (14) office buildings in an effort to measure and compare design approaches and construction practices used to produce green buildings. Not all of these buildings received a rating from the United States Green Building Council (USGBC) or from any other group, but each was purported to have some green features. This study attempted to create a common foundation for green evaluation by comparing elements that are common to both.

The eight categories defined in the 'LEED for Homes' rating system were used as the basis of the comparison to create commonality throughout the documentation. Elements associated with water use/conservation and energy conservation were the most common, spanning both home and new construction. While green elements associated with water use, energy, and indoor environmental quality were more prevalent in the office buildings surveyed, elements tied to Location/Linkages and Materials/Resources were slightly more prevalent in home construction.

Introduction

Buildings account for the largest source of energy consumption in America. An estimated 43 percent of all greenhouse emissions are attributable to buildings, compared to 32 percent for transportation and 25 percent for industry (Rainwater 2007). In light of these numbers, the design and construction of green buildings presents an opportunity to address the issue of energy consumption and emissions that result from building construction and operation.

The purpose of this study was to analyze and compare the elements used in both green office buildings and single-family homes. "Elements" are defined as design approaches and construction practices that make a building efficient with respect to resource use, either in the near-term, or over the building's operational life. Comparing green elements used in homes versus office buildings is unique because the green criteria used by organizations and agencies for scoring are different for homes and office buildings. Thus, an effort was

made to develop a list of common elements used in both homes and office buildings and to explore if specific practices were more common to homes or office buildings.

"Building green" has often focused on resources used in the structure itself, but a broader approach to include community impact and overall resource use has emerged. For example, rating agencies now include such factors as a building's proximity to public transportation and its accessibility to schools and shopping hubs in their scoring rubrics. Some rubrics also consider land use as well. Was the building constructed on a pre-existing building site or was undeveloped land used? (Zigenfus 2008) These are also considered herein as 'elements.'

Background

A main focus of this investigation involved the study of available information pertaining to the criteria used to evaluate the level of greenness in office buildings and single-family homes. This study investigated a mixture of both single-family homes and office buildings and looked at green elements that were common for both types of buildings. Examining both existing homes and office buildings in a single group affords the opportunity to determine if there are common elements that architects and builders have focused on in when designing and building their projects. This approach could be revealing when reviewing common elements, especially since there was no requirement for the buildings used in this study to have received certification from LEED, NAHB, nor any other agency or organization.

The literature search lead to three significant sources that provide guidance in the design and construction of green buildings along with scoring rubrics used to evaluate buildings. Information provided by the United States Department of Energy (USDOE), the National Association of Home Builders (NAHB), and United States Green Building Council (USGBC) served as the foundation of the analysis.

The USDOE has developed recommended green practices for commercial buildings. The various topics covered in their recommended practices ("Commercial Buildings Site Design and Planning," 2009) were referenced in an effort to ensure that all possible green elements in a given LEED for Homes category were included for consideration. For example, in the LEED for homes category of Innovation/Design, specific topics such as minimizing disruption to native vegetation, minimizing erosion and runoff during construction, and consideration of a Heat Island effect are not mentioned. However the USDOE guidelines do include these topics in their Innovation/Design topic area. As such, any elements that aligned with the USDOE guidelines were included in the associated LEED for Homes category.

The NAHB is a trade organization representing the residential building industry. It is a federation of more than 800 state and local builders' associations ("About NAHB," 2009). In 2006 the NAHB developed a program called Model Green Home Building Guidelines. The following year saw publication of the "National Green Building Standard," which was adopted by the International Code Council in January, 2009. The newer Standard is similar to the Guidelines. The Standard, however, "includes more mandatory items and suggests that higher thresholds be met in several categories." ("National Green Building Standard," 2009). The categories used for measuring a home's performance in the NAHB "National Green Building Standard" are similar in nature to the LEED for home categories, but not identical ("National Green Building Standard," 2009).

Rating systems programs have been developed by the USGBC for different types of construction. Each type of construction shown in Figure 1 below carries its own set of performance criteria, as defined in the LEED rating system.

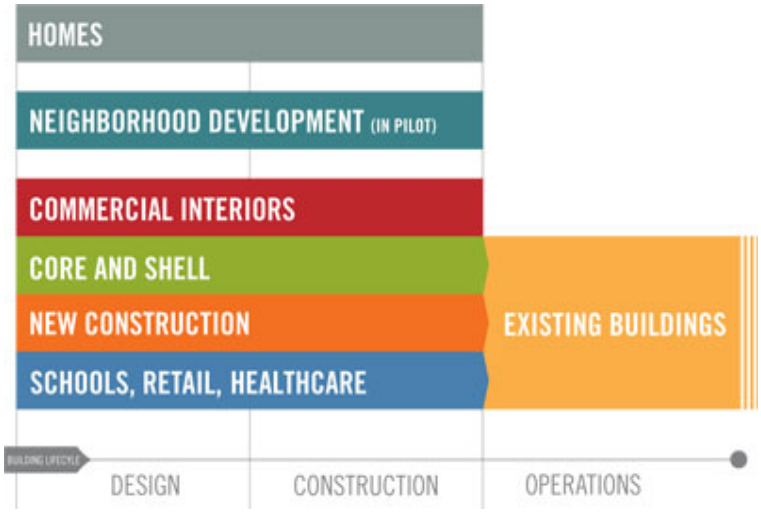

Figure 1 LEED rating systems ("LEED Rating System," 2009)

Each program has a unique rating system that measures performance in different categories as shown above. To receive a LEED certification a building must meet the criteria in the appropriate program.

The 2009 LEED v3 rating system for New Construction includes seven categories (LEED 2009 New Construction..," 2009). Five of the seven categories are identical to those used in the LEED for Homes rating system. A regional priority category is added (encouragement for addressing geographically-specific environmental priorities), and location & linkage and awareness and education are removed. The fourteen office buildings covered in this research, if evaluated in isolation, would fall into LEED's rating system for "new construction."

In this study, the categories described in the LEED rating system for Homes were used as the basis for comparison. These eight categories used to measure performance for homes are ("LEED for Homes Rating System," 2008):

1. Innovation & Design Process –Special design methods, unique regional credits, measures not currently addressed in the rating system, and exemplary performance levels.
2. Location & Linkages – The placement of homes in socially and environmentally responsible ways in relation to the larger community.
3. Sustainable Sites – The use of the entire property so as to minimize the project's impact on the site.
4. Water Efficiency – Water-efficient practices, both indoor and outdoor.
5. Energy & Atmosphere – Energy efficiency, particularly in the building envelope and heating and cooling design.
6. Material & Resources – Efficient utilization of materials, selection of environmentally preferable materials, and minimization of waste during construction.

7. Indoor Environmental Quality – Improvement of indoor air quality by reducing the creation of and exposure to pollutants.

8. Awareness & Education - The education of homeowners, tenant, and/or building manager about the operation and maintenance of the green features of a LEED home.

Methodology

The categories used in the United States Green Building Council's LEED ("LEED for Homes Rating System," 2008) rating system were used to group the elements. The rating categories and associated criteria for LEED for New Construction, NAHB's National Green Building Standard, and the USDOE's guidelines for commercial building were used in developing a list of green elements appropriate for each category. The research examined the green elements used at a group of recently completed buildings across the continental US. The group was selected based on the availability of accessible information relating to the use of green 'elements' in design and/or construction. A database was developed that contained detailed information about each of the thirty buildings surveyed. The elements were then grouped within the appropriate 'LEED for Home' scoring categories.

Research identified the specific types of green elements that were used by designers and contractors in the construction of single-family homes and office buildings. The outcome was the creation of a list with descriptions of each practice that was considered green for each of the thirty buildings surveyed. Findings were grouped by the following characteristics:

- Reference number (one to thirty) which allows for reader tracking of particular projects studied.
- Type of building (single-family home or office)
- Location

A description of the green elements used in each building was also completed. Effort was made record the cost of each building, but this study did not make an attempt to correlate cost with the green elements used. As mentioned, a green rating was not required for a building in order for it to be used in the survey (Zigenfus 2008).

In order to create commonalty in this report, the categories developed by LEED for Homes were used. This was done because LEED for Homes is comprehensive and covers a majority of green building aspects. This study does not favor using LEED for Homes over any other descriptive or rating system, but merely used the eight categories as a method for grouping similar green building elements (Zigenfus 2008).

Green elements for the buildings surveyed were then grouped within the appropriate LEED for Home category:

1. Innovation and Design Process:
    - Cooling with vegetation
    - Roof Design
    - Wetland for cooling
    - Unique air moving systems
    - Use of on-site materials
    - Location for solar use

- Geothermal system
- Heat reflecting material in construction
- Universal Design

2. Location and Linkages
    - Located near public transportation
    - Siting of building
    - Built on pre-existing site
    - Public use buildings nearby
    - Preserves local history
3. Sustainable Sites
    - Reduce heat island effect
    - Partial or full green roof
    - Collects more rainwater than can be used
    - Native plantings
    - On-site building materials
    - 70% or more construction waste recycled
    - Near public transportation
    - On-site geothermal system
4. Water Efficiency
    - Collect rainwater
    - Retention Ponds
    - Greywater used
    - Bioreactor
    - Closed loop heat system
    - Green roof
    - Waterless urinals
    - Use native plants
    - Water efficient fixtures
5. Energy and Atmosphere
    - Green roof

- Solar power
- Wind power
- Geothermal heat source
- Air flow system for cooling
- Energy saving appliances and devices
- Non-CFC cooling devices
- Shade providing techniques

6. Materials and Resources

- Use of materials made from recycled materials
- Cellulose insulation
- Low impact materials
- FSC certified wood
- Concrete insulated forms

7. Indoor Environmental Quality

- Shading
- Noise controls
- Daylighting
- Interior lighting control
- Outside air control system
- Radon evacuation system

8. Awareness and Education

- Education program

Results

Tables are provided for each of the eight LEED for Homes categories and the elements associated with that category. A total of the number of homes and office building for each of the elements within the category is provided. (Zigenfus 2008).

1. Innovation and Design Process

Innovation and Design Process is defined as special design methods or unique reasons for adding green to a construction project. What within the project stands out from most other similar type of construction activity? Innovation and design starts with the planning and include creative ways to achieve green. There are a number of innovative designs used that allow a structure to become more efficient in resource use and conservation of energy. Table 1 lists those sites that exhibit unique design.

There are nineteen sites (63% of the 30 sites) exhibiting characteristics for at least one of the nine elements within innovation and design. Roof design, three each for home and office building were included more than any other practice in the construction. Other elements with higher ranking include unique air moving systems and use of on-site materials. Based on the data there are fourteen (61%) practices exhibited by office building verses nine (39%) for the single family home (Zigenfus 2008).

Table 1
Innovation and design

ID Number	Building Type	Location	Cooling w/vegetation	Roof design	Wetland for cooling	Unique air moving systems	Use of on-site materials	Location for solar use	Geothermal system	Heat reflecting material in construction	Universal design	Footnote
10	Home	Rockland, Calif.										3
11	Home	Freeport, Maine		X				X				3
13	Home	San Diego, Calif.					X					3
14	Home	Gainesville, Fla.								X		4
20	Home	Kerhonkson, N.Y.							X			7
22	Home	Chicago, Ill.		X								7
24	Home	Glenville, N.Y.									X	9
28	Home	Venice, Calif.		X				X				12
8		**Total Home**		**3**			**1**	**2**	**1**	**1**	**1**	
1	Office	Washington, D.C.				X						1
2	Office	Providence, R.I.	X	X			X					2
3	Office	Overland, Missouri										1
4	Office	Little Rock, Arkansas		X								1
5	Office	Little Rock, Arkansas			X	X						1
6	Office	Portland, Oregon		X		X						2
7	Office	Stanford, Calif.				X						2
8	Office	Berkeley, Calif.					X					2
9	Office	Boise, Idaho							X			3
26	Office	Denver, Colorado						X				10
29	Office	Chelmsford, Mass.					X					10
11		**Total Office**	**1**	**3**	**1**	**4**	**3**	**1**	**1**			
19		**TOTAL OVERALL**	**1**	**6**	**1**	**4**	**4**	**3**	**2**	**1**	**1**	

2. Location and Linkages

The location and linkages element is defined as the placement of homes in socially and environmentally responsible ways in relation to the larger community. There are historic, economic, or even community related reasons for locating at a specific site. Location of the project in relation to public transportation, revitalizing contaminated sites or building on sites that contain or did contain prior structures is another part of this element. Table 2 lists the sites with the applicable impacted element.

There are twenty-one sites (70% of the 30 sites) exhibiting characteristics for at least one of the five elements within the location category. Six homes and four offices for a total of ten, exhibited the 'siting' element. Other elements with a higher ranking include location near public transportation (a total of seven) and built on pre-existing sites (a total of six). Based on the data there are eleven (41%) elements exhibited by office building verses sixteen (59%) for the single family home (Zigenfus 2008).

Table 2
Location

ID Number	Building Type	Location	Located near public transportation	Siting of building	Built on pre-existing site	Public use buildings nearby	Preserves local history	Footnote
10	Home	Rockland, Calif.	X			X		3
13	Home	San Diego, Calif.					X	3
14	Home	Gainesville, Fla.		X				4
16	Home	Boulder, Colorado	X		X			6
19	Home	Boulder, Colorado			X			6
20	Home	Kerhonkson, N.Y.		X				7
21	Home	Evanston, Ill.		X				7
22	Home	Chicago, Ill.	X	X	X	X		7
24	Home	Glenville, N.Y.		X				9
27	Home	Tukwila, Wash.	X					11
28	Home	Venice, Calif.		X				12
11		**Total Home**	**4**	**6**	**3**	**2**	**1**	
1	Office	Washington, D.C.		X				1
2	Office	Providence, R.I.		X				2
3	Office	Overland, Missouri		X				1
5	Office	Little Rock, Arkansas			X			1
6	Office	Portland, Oregon	X					2
9	Office	Boise, Idaho	X			X		3
25	Office	Washington, D.C.			X			10
26	Office	Denver, Colorado	X					10
29	Office	Chelmsford, Mass.		X				10
30	Office	Arlington, Va.			X			10
10		**Total Office**	**3**	**4**	**3**	**1**		
21		**TOTAL OVERALL**	**7**	**10**	**6**	**3**	**1**	

3. Sustainable Sites

A sustainable site can use the entire property so as to minimize the project's impact on the site. A sustainable site can involve a project that utilizes existing natural resources, or uses resources that require less material. Many of the sites in this study used native plants in their landscaping scheme thereby reducing water demands and labor needed for maintenance. Some sites in the study use on-site material in constructing the building. Recycling of construction waste, ranging from 62% to 85%, was utilized at many of the sites. Table 3 lists the sites with sustainable aspects.

There are twenty-five sites (83% of the 30 sites) exhibiting characteristics for at least one of the eight elements within the Sustainable Sites category. Use of native plantings was a popular green element. Other elements with higher ranking include use of on-site building materials (a total of six) and 70% or more of construction materials were recycled (a total of five). Based on the data, there are sixteen each of the elements exhibited by the home and office building (Zigenfus 2008).

Table 3
Sustainable Sites

ID Number	Building Type	Location	reduced heat island effect	Partial or full green roof	Collects more rainwater than can be used	Native plantings	On-site building materials	70% or more construction waste recycled	Near public transportation	On-site geothermal system	Footnote
10	Home	Rockland, Calif.						X			3
11	Home	Freeport, Maine				X	X				3
12	Home	Westwego, Louisiana									3
13	Home	San Diego, Calif.				X	X				3
14	Home	Gainesville, Fla.				X		X			4
18	Home	Charleston, R.I.				X	X				7
19	Home	Boulder, Colorado				X					6
20	Home	Kerhonkson, N.Y.								X	7
21	Home	Evanston, Ill.					X				7
23	Home	Santa Monica, Calif.				X					8
24	Home	Glenville, N.Y.				X					9
27	Home	Tukwila, Wash.				X					11
28	Home	Venice, Calif.					X				12
13		**Total Home**				**8**	**5**	**2**		**1**	
1	Office	Washington, D.C.	X	X							1
2	Office	Providence, R.I.		X							2
4	Office	Little Rock, Arkansas			X						1
5	Office	Little Rock, Arkansas				X					1
6	Office	Portland, Oregon		X					X		2
7	Office	Stanford, Calif.				X					2
8	Office	Berkeley, Calif.				X		X			2
9	Office	Boise, Idaho							X	X	3
25	Office	Washington, D.C.						X			10
26	Office	Denver, Colorado						X			10
29	Office	Chelmsford, Mass.				X	X				10
12		**Total Office**	**1**	**3**	**1**	**4**	**1**	**3**	**2**	**1**	
25		**TOTAL OVERALL**	**1**	**3**	**1**	**12**	**6**	**5**	**2**	**2**	

4. Water Efficiency

The water-efficient category includes reducing potable water usage and utilizing grey water and/or recycled water for irrigation. Table 4 shows the major water saving elements from the sites examined. The control of storm water runoff is also an important aspect in this category. Water use and the reduction therein was an important consideration for most of the sites examined. The use of waterless urinals and low flow faucets was very common among the sites examined. Use of captured water for irrigation was utilized on a number of the projects. A number of sites utilize water collection systems for various uses ranging including irrigation and HVAC applications.

There are twenty-two sites (73% of the 30 sites) exhibiting characteristics for at least one of the nine elements within the water efficiency category. Five homes and nine office buildings used some form of rainwater collection system. This was followed by use of native plants and green plants as the most often used elements in the category. Based on the data there are thirty-one (66%) elements exhibited by office building verses sixteen (34%) for the single family home (Zigenfus 2008).

Table 4
Water Efficiency

ID Number	Building Type	Location	Collect rainwater	Retention Ponds	Greywater used	Bioreactor	Closed loop heat system	Green roof	Waterless urinals	Use native plants	Water efficient fixtures	Footnote
11	Home	Freeport, Maine								X		3
12	Home	Westwego, Louisiana										3
13	Home	San Diego, Calif.					X			X		3
14	Home	Gainesville, Fla.	X				X			X		4
18	Home	Charleston, R.I.	X							X		7
19	Home	Boulder, Colorado								X		6
22	Home	Chicago, Ill.	X					X				7
23	Home	Santa Monica, Calif.	X					X		X		8
24	Home	Glenville, N.Y.	X							X		9
27	Home	Tukwila, Wash.	X							X		11
10		**Total Home**	**5**				**2**	**2**		**7**		
1	Office	Washington, D.C.	X					X	X		X	1
2	Office	Providence, R.I.	X						X	X		2
3	Office	Overland, Missouri	X	X					X	X		1
4	Office	Little Rock, Arkansas	X									1
5	Office	Little Rock, Arkansas	X		X				X			1
6	Office	Portland, Oregon	X			X		X				2
7	Office	Stanford, Calif.						X				2
8	Office	Berkeley, Calif.							X		X	3
9	Office	Boise, Idaho	X		X							10
25	Office	Washington, D.C.									X	10
26	Office	Denver, Colorado	X					X			X	10
29	Office	Chelmsford, Mass.								X	X	10
12		**Total Office**	**9**	**1**	**2**	**1**		**4**	**5**	**4**	**5**	
22		**TOTAL OVERALL**	**14**	**1**	**2**	**1**	**2**	**6**	**5**	**11**	**5**	

5. Energy and Atmosphere

Energy and atmosphere elements concern the energy efficiency, particularly in the building envelope, and heating and cooling design. Table 5 shows the sites with elements within the energy and atmosphere category exhibiting criteria. The use of alternate sources of energy such as wind, solar or thermal energy sources are important aspects in this category. Energy was an important focus at each of the sites in the study. Many of the designs used solar power and heating as a major component of the energy plan.

There are twenty-eight sites (93% of the 30 sites) exhibiting characteristics for at least one of the eight elements within the energy and atmosphere category. Solar power, featured in nine of the homes and five of the office buildings, was included more than any other element in the construction. Other elements with higher ranking included energy savings appliances and devices as well as the use of air flow systems for cooling. Based on the data there are twenty-four (52%) elements exhibited by office buildings verses twenty-two (48%) for single family homes (Zigenfus 2008).

Table 5
Energy and Atmosphere

ID Number	Building Type	Location	Green roof	Solar Power	Wind Power	Geothermal heat source	Air flow systems for cooling	Energy saving appliances and devices	Non-CFC cooling devices	Shade providing techniques	Footnote
10	Home	Rockland, Calif.		X							3
11	Home	Freeport, Maine		X							3
12	Home	Westwego, Louisiana						X			3
13	Home	San Diego, Calif.		X							3
14	Home	Gainesville, Fla.					X	X			4
15	Home	Boulder, Colorado		X							5
18	Home	Charleston, R.I.		X						X	7
19	Home	Boulder, Colorado						X			6
20	Home	Kerhonkson, N.Y.				X					7
21	Home	Evanston, Ill.		X							7
22	Home	Chicago, Ill.	X				X				7
23	Home	Santa Monica, Calif.	X	X			X				8
24	Home	Glenville, N.Y.						X			9
27	Home	Tukwila, Wash.		X				X			11
28	Home	Venice, Calif.		X						X	12
15		**Total Home**	**2**	**9**		**1**	**3**	**5**		**2**	
1	Office	Washington, D.C.						X			1
2	Office	Providence, R.I.	X	X					X		2
3	Office	Overland, Missouri		X	X			X			1
4	Office	Little Rock, Arkansas					X			X	1
5	Office	Little Rock, Arkansas					X				1
6	Office	Portland, Oregon		X			X				2
7	Office	Stanford, Calif.					X				2
8	Office	Berkeley, Calif.						X			2
9	Office	Boise, Idaho				X	X				3
25	Office	Washington, D.C.						X			6
26	Office	Denver, Colorado	X	X			X			X	10
29	Office	Chelmsford, Mass.		X				X			10
30	Office	Arlington, Va.						X			10
13		**Total Office**	**2**	**5**	**1**	**1**	**6**	**6**	**1**	**2**	
28		**TOTAL OVERALL**	**4**	**14**	**1**	**2**	**9**	**11**	**1**	**4**	

6. Material and Resources

The Materials and resources category covers the efficient utilization of materials, selection of environmentally preferable materials, and minimization of waste during construction. Also, the use of recycled materials or materials with recycled content is an important green element in this category. A building in Little Rock, Arkansas, (Site Number 5), was erected on a site where a prior building was demolished. The new structure was built with 97% of the materials coming from the former on-site building or nearby buildings. Many sites complied with the LEED requirement that materials be purchased from sources within 500 miles. This was true even for sites that did not receive a LEED certification. The use of FSC certified wood products and bamboo for flooring was common. Many of the building materials themselves are made from recycled components including concrete made using fly-ash, and gypsum board made from recycled materials used as insulation. Table 6 lists the sites and those with applicable material and resource issues.

There are twenty-five sites (83% of the 30 sites) exhibiting characteristics for at least one of the nine elements within materials and resources category. See table 6. Low impact materials, six each for homes

and eight for office buildings were included more than any other element in the construction. Based on the data there are seventeen (49%) elements exhibited by office buildings verses eighteen (51%) for single family homes.

Table 6
Materials and Resources

ID Number	Building Type	Location	Use of materials made from recycled materials	Cellulose insulation	Low impact materials	FSC certified wood	Concrete insulated forms	Footnote
10	Home	Rockland, Calif.			X			3
12	Home	Westwego, Louisiar	X					3
14	Home	Gainesville, Fla.		X	X			4
15	Home	Boulder, Colorado		X	X			5
16	Home	Boulder, Colorado	X					6
18	Home	Charleston, R.I.				X		7
19	Home	Boulder, Colorado	X		X			6
21	Home	Evanston, Ill.				X		7
22	Home	Chicago, Ill.	X		X			7
24	Home	Glenville, N.Y.	X				X	7
27	Home	Tukwila, Wash.			X	X		11
28	Home	Venice, Calif.	X					12
12		**Total Home**	**6**	**2**	**6**	**3**	**1**	
1	Office	Washington, D.C.	X					1
2	Office	Providence, R.I.		X	X			2
4	Office	Little Rock, Arkansa	X					1
5	Office	Little Rock, Arkansa	X					1
7	Office	Stanford, Calif.	X		X			2
8	Office	Berkeley, Calif.			X	X		2
9	Office	Boise, Idaho			X			3
17	Office	Boulder, Colorado			X			6
25	Office	Washington, D.C.	X		X			10
29	Office	Chelmsford, Mass.	X		X			10
30	Office	Arlington, Va.			X	X		10
13		**Total Office**	**6**	**1**	**8**	**2**		
25		**TOTAL OVERALL**	**12**	**3**	**14**	**5**	**1**	

7. Indoor Environmental Quality

The elements in this category, as shown in Table 7, involve the improvement of indoor air quality by reducing the creation of and exposure to pollutants. Indoor comfort associated with temperature, noise and light levels is an important environmental concern. Elements within this category include interior lighting provided through skylights/windows and control of the lighting through shades with manual or automatic

controls. Other environmental quality elements include interior temperature comfort, fresh air provided from outside the building, ability to control individual office temperatures, and use of low emitting materials such as VOC's.

There are twenty-four sites (80% of the 30 sites) exhibiting characteristics for at least one of the six elements. Daylighting, ten each for homes and office buildings were included more than any other element in the construction. Based on the data there are twenty-two (61%) elements exhibited by office buildings verses fourteen (39%) for single family homes (Zigenfus 2008).

Table 7
Indoor Environmental Quality

ID Number	Building Type	Location	Shading	Noise controls	Daylighting	Interior lighting control	Outside air control system	Radon evacuation system	Footnote
10	Home	Rockland, Calif.					X		3
11	Home	Freeport, Maine			X				3
15	Home	Boulder, Colorado			X				5
18	Home	Charleston, R.I.			X		X	X	6
19	Home	Boulder, Colorado			X				6
21	Home	Evanston, Ill.			X				7
22	Home	Chicago, Ill.			X				7
23	Home	Santa Monica, Calif.			X				8
24	Home	Glenville, N.Y.			X			X	9
27	Home	Tukwila, Wash.			X				11
28	Home	Venice, Calif.			X				12
11		**Total Home**			**10**		**2**	**2**	
1	Office	Washington, D.C.	X			X			1
2	Office	Providence, R.I.			X				2
3	Office	Overland, Missouri			X				1
4	Office	Little Rock, Arkansas			X				1
5	Office	Little Rock, Arkansas	X		X	X			1
6	Office	Portland, Oregon	X		X	X			2
7	Office	Stanford, Calif.			X				2
8	Office	Berkeley, Calif.			X		X		2
9	Office	Boise, Idaho					X		3
25	Office	Washington, D.C.		X	X				10
26	Office	Denver, Colorado			X		X		10
29	Office	Chelmsford, Mass.			X		X		10
30	Office	Arlington, Va.					X		10
13		**Total Office**	**3**	**1**	**10**	**3**	**5**		
24		**TOTAL OVERALL**	**3**	**1**	**20**	**3**	**7**	**2**	

8. Awareness and Education

Awareness and education provides information to the homeowner, tenant, and/or building manager about the operation and maintenance of the building's green features. Of the thirty sites described in the research data, only two office buildings documented the implementation of a program for awareness and education. See table 8. The Boise, Idaho (Site Number 9) features a knowledge wall inside the building while the

Arlington, Virginia building (Site Number 30) showcases a user education program in which signs are placed throughout the building to provide information to visitors. It is interesting to note that only two office sites implemented this element, as awareness and educational efforts serve to not only highlight the efforts undertaken, but also increase their potential long term effect. In addition, the teaching signage and labeling used are fairly simple to implement for any space (Zigenfus 2008).

Table 8
Awareness and Education

ID Number	Building Type	Location	Education Program	Footnote
9	Office	Boise, ID	X	3
30	Office	Arlington, Va.	X	10
2		**Total Office**	**2**	

Table 9 summarizes the data from Tables 1 through 8. Office buildings ranked higher than homes in five out of the eight categories in the number of times an element was applied. Somewhat of a surprise is that homes scored higher than office buildings in the location and material/resources categories. The sustainable sites category had an even number of elements applied to the two types of construction.

Table 9 Summary of Data

CATEGORY	Innovation/Design	Location	Sustainable	Water	Energy/Atmosphere	Material/Resources	Indoor Environmental Quality	Awareness/Education
Total # of elements within category	9	5	8	9	8	5	6	1
Total Sites with elements in this category	19	21	25	22	28	25	24	2
Home	8	11	13	10	15	12	11	0
Office	11	10	12	12	13	13	13	2
Total # of elements of the sites that met this category	23	27	32	47	46	35	36	2
Home	9	16	16	16	22	18	14	0
Office	14	11	16	31	24	17	22	2

The innovation in the design for both types of construction had a range from minimal to extraordinary. An impressive design was that of the staircase and wetland design used at the Heifer International Center in Little Rock, Arkansas (Site number 5). This design used available clay soil located on site to create a base for a wetland. The wetland is used to collect storm water. Stair towers adjacent to the wetland serve to circulate warm air up and out of the building. The air passes over the wetland and is cooled before entering the building.

Water use and energy were by far the most significant issues for designers and owners in this study. The office buildings in the research feature some significant plans for capturing and reusing water. For example, the Wincock International building in Little Rock, Arkansas (Site number 4), uses an underground cistern for water collection. Excess water that cannot be held in the cistern is stored in a nearby underground reservoir. The water is used for irrigation with excess water used by a nearby marina. Another example of water collection and reuse occurs in a Boise, Idaho (Site number 9) building that collects water from on-site and nearby streets and parking lots. The water is used for irrigation while grey water from the building is used to flush toilets (Zigenfus 2008).

Not surprisingly, water capture and reuse plans were more developed for office buildings. Nevertheless, there are examples of significant water capture and reuse by single-family homes as well. For example, the Charleston, Rhode Island home (Site Number 19), captures and reuses water for irrigation. Green roofs were also used by both office buildings and single family homes. The roofs absorb rainwater and heat, keeping the structures naturally cooler.

A significant green element common to both types of buildings is energy use. Production of on-site electricity using solar cells and wind turbines, along with the use of air flow, green roofs, cooling water, advanced insulation, and ENERGY STAR ™ appliances are methods used to reduce energy costs. Overall energy reductions also are important in terms of building siting in relation to public transportation. In comparing the energy element of the single family home to the office building there seems to be very similar use of technology. For example, solar heating and photovoltaic cells are used in a number of instances for both types of buildings. Eight of the sixteen single family homes and six of the fourteen office buildings use solar power. Offices in Overland, Missouri, (Site Number 3), and Boulder, Colorado, (Site Number 17), also use wind turbines to produce electricity. There were no single family homes using wind turbines to produce electricity (Zigenfus 2008).

Conclusions

This study intended to include a review the elements that make a building green and complete a survey of buildings The survey included thirty buildings, both office and single-family. The structures were purported to include one or more green elements. The limitation of the research was that only a relatively small sample was taken.

Categories used for quantifying levels of ‘greenness’ from different agencies were compared. The differences in category descriptions for varying types of construction (homes versus new construction) are minor. Moreover, the difference in category description between agencies is minor as well.

Green elements common to both home and new construction were sorted by the LEED for Homes categories. Elements associated with water use/conservation and energy conservation were the most common, spanning both home and new construction. The original research question revolved around a comparison of green elements employed in home and office building construction. While green elements associated with water use, energy, and indoor environmental quality were more prevalent in office construction, elements tied to Location linkages and Materials/Resources were slightly more prevalent in home construction. As noted by this review of these projects, green building practices once only emerging, are now beginning to standardize into particular elements. While green construction will remain innovative, it will benefit from increased standards of practice and common knowledge.

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