

Commercial LEED Ideals in Residential Applications

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The Leadership in Energy and Environmental Design (LEED) building standards has substantially influenced sustainable or "green" construction practices over the past decade. This has impacted the commercial building sector and influenced the way architects, owners, and builders examine the attributes and overall value of a commercial building. However, the complexities and challenges of residential construction have inhibited the growth of sustainable practices in this market. In hopes to simplify green implementation for the smaller builder and consumer, this study investigates the possibility of utilizing successful commercial green construction practices and their fit in residential applications. Two ranking system databases containing the most frequently used sustainable commercial building practices were combined and compared to determine top common applications. From this, fifteen commercial LEED point commonalities were identified and then statistically compared to a survey of residential builder perceptions that were detailed in the 2006 Residential Green Building Smart Market Report by McGraw Hill Construction. A Spearman correlation infers that there is not a statistically significant correlation between the top commercial sustainable practices and the viewpoints held by the residential building companies. It was concluded that each construction sector should be analyzed and reviewed individually, thus negating any ease of commercial sustainable practice adaptation into residential applications.

Keywords: Sustainability, Residential Construction, Green Standards, Builders.

Introduction

The residential and commercial industry is responsible for 72% of all the electricity consumption and 40% of all the U.S.'s primary energy consumption (Environmental Information Administration, 2013). Understanding the responsibility as an industry and recognizing some known improvement areas, the United States Green Building Council (USGBC) set out to implement wide spread industry standards focusing on energy and environmental design, known as Leadership in Energy and Environmental Design (LEED). It was first introduced in 1998 by the U.S. Green Building Council as a program aimed at improving performance across all the metrics that matter most: energy savings, water efficiency, CO2 emissions reduction, improved indoor environmental quality, and stewardship of resources and sensitivity to their impacts (United States Green Building Council, 2010).

Since inception, it has grown from an internationally accepted green building rating system for commercial buildings into an entity that provides a rating system for every type of construction from commercial to residential. With the influence of the LEED building standards, sustainable or "green" construction practices over the past decade have influenced the commercial building sector and changed the way architects, owners, and builders examine the attributes and overall value of a building. Because of LEED's direct influence, the green marketplace has captured 13% of the commercial sector and close to 40% of total square footage (Kok, 2014). The success in the commercial sector led the USGBC to develop multiple building standards for specific needs, e.g. Core and Shell, Schools, Healthcare, Retail, Commercial Interiors, and Existing Buildings. A LEED for Homes rating system was first introduced in 2005 as a pilot program. By 2008 it was formally established as an official rating system that promotes the design and construction of high-performance green homes (United States Green Building Council, 2010). It entered the marketplace in direct competition with the National Association of Home Builders (NAHB) "Green Standards" rating system. Both the NAHB's "Green Standards" and LEED's "Homes" set out to mimic the success of their commercial counterpart; however, the overwhelming differences of end-users, constructor types and market practices were either significantly undervalued or simply ignored.

The residential construction sector has always been a disaggregated sector of the United States economy. With the numerous challenges and impediments facing the residential sector, is it possible to take the sustainable successes of the commercial sector and effectively apply them to the residential market? To investigate this question, this study uses three separate databases to identify the most commonly obtained LEED points in the commercial building sector and compares the results to current building practices for residential construction. Over the past decade sustainable building practices have slowly begun to change the landscape of the construction industry as the world becomes aware of the depletion of earth's natural resources. In order for this realization to take place, there has to be a driver behind this movement. Augenbroe and Pearce (1998) identified many drivers for change that have emerged and stood the test of time as a result of the US construction industry's response to sustainability. They provide a means to successfully implementing certain sustainable building practices into the residential sector. These individual drivers (Augenbroe & Pearce, 1998) are as follows:

- energy conservation measures
- land use regulations and planning policies
- waste reduction measures
- resource conservation strategies
- indoor environmental quality
- environmentally-friendly technologies
- re-engineering and the design process
- proactive role of materials manufactures

- better ways to measure for costs
- new kinds of partnerships/stakeholders
- adoption of performance-based standards,
- product innovation and certification
- adoption of incentive programs
- education and training
- buildings as productivity assets

To further validate the drivers, a survey was conducted to rank the 15 drivers for change based on their significance with respect to two different considerations (Augenbroe & Pearce, 1998):

1. How important is the topic to sustainable construction in the US?
2. How should the topics be prioritized in order to achieve sustainable construction?

Survey results indicated, in both considerations, energy conservation, land use regulations, and education/training respectively placed in the top three levels of significance.

It is very prevalent that sustainable design practices and programs have started to take shape in residential construction with the implementation of national rating systems and various local government programs. Although these have gained popularity, they still are not experiencing the widespread success that other LEED programs have experienced. The United States Green Building Council (2010) believes one of the main reasons for lack of implementation is that LEED for Homes only targets 25% of the new homes residential market by targeting designers, rather than the building company and consumer.

Residential construction has begun to take on some of the same eco-friendly responsibilities that have been seen in commercial construction for years. Related research on this has made it clear that education, government regulations and incentives are three of the biggest drivers for the success of sustainable building practices currently being used. For example, Executive Order 13423, called Strengthening Federal Environmental, Energy, and Transportation Management, was put into law January 24, 2007 by President George W. Bush. It provided a mandatory government regulation for sustainable building practices. The Executive Order states that it is the policy of the United States that Federal agencies conduct their environmental, transportation, and energy-related activities under the law in support of their respective missions in an environmentally, economically and fiscally sound, integrated, continuously improving, efficient, and sustainable manner. Moreover, there are numerous Federal and State incentives providing tax breaks for entities that practice sustainable and energy efficient building practices. A list of these state, local, utility, and federal incentives can be found on-line in the Database of State Incentives for Renewable & Efficiency (North Carolina State University, 2010). After reviewing both Federal regulations and incentives, it becomes obvious that the majority of these are specifically aimed at the Federal and State levels. To ensure the future of and increase the use of sustainable building practices in the residential sector, regulations and incentives will need to be developed that specifically targets individual residential properties.

With this movement in the residential sector of the economy, it is important to identify the driving force and influences in the market. One such driving force questioned by the researchers of this study involved the influence of the "big brother" - the commercial building sector. Research completed for this study provided insight for the industry through a correlation analysis of the commercial and residential sectors. It was originally envisioned the residential industry could build upon the past successes of the commercial with minimum effort. Using data obtained from the literature, this hypothesis was explored.

Methodology

An analysis of LEED points obtained by Canadian building projects provided an understanding of how projects have utilized LEED credits in the past (Siliva & Ruwanpura, 2009). This study improved the application of sustainable features in future developments and enabled project teams to more effectively implement LEED. It also defined the most common sustainable commercial building practices and demonstrated differences in the points obtained by LEED projects in Canada and the United States. It was found that the main reason for disparities in points awarded in Canada verses the United States was based on different climate and regional locations and not alternate construction practices and/or cost. The database published by Davis Langdon provided the comprehensive cost database analysis of over 600 United States LEED commercial projects (Matthiessen & Morris, 2004). A similar residential survey took a representative sample of 75,000 builders from a list obtained by the National Association of Home Builders (McGraw-Hill Construction, 2006). These builders were asked specifically on their viewpoint of "Green" and its influence on their building marketplace. This data was then used in 2006 by the McGraw Hill research team in its Residential Green SmartMarket Report.

The studies from the Canadian Building Projects (Siliva & Ruwanpura, 2009) and the Landon Costing Database (Matthiessen & Morris, 2004) were analyzed and used to identify top ranked LEED commercial applications. They were tabulated and placed in a ranking system that indicated the most frequently used sustainable building practices. Since Canada and the U.S. utilized the same LEED criteria, this effort could be combined with the work completed by the Davis Langdon knowledgebase. It provided LEED information on U.S. commercial projects in a similar format to the Canadian study. With the addition of cost, more than one hundred LEED projects were used for sampling to determine the most frequently used sustainable building practices. To establish a similar ranking for the residential industry, survey results taken by McGraw Hill (2006) were used placing the top 25 green building techniques in order of viewed importance by the representative builders. There was not enough information within the data set to test the normality or homoscedasticity assumptions typically found in linear regression and correlation methods. Considering the main research question attempts to shed light on how commercial and residential practices correlate, removing "outliers" or the largest points of variance would be inappropriate to the central theoretical question. With the small sample size, a non-parametric Spearman correlation test was used to test the relationships between the commercial and residential ranking variables:

Whereas: r = Spearman correlation coefficient
d = differences between ranks
n = total number of ranks

$$r = 1 - \frac{6\sum d^2}{n(n^3-1)}$$

The USGBC (United States Green Building Council) developed the LEED rating system with six distinct categories with scoring comprising of seven prerequisites and sixty-nine elective points (Matthiessen & Morris, 2004). Each category is given an assortment of topics in which to achieve LEED points. The LEED categories are as follows:

1. SS – Sustainable Sites
2. WE – Water Efficiency
3. EA – Energy and Atmosphere
4. MR – Material and Resources
5. IEQ – Indoor Environmental Quality
6. ID – Innovation and Design Process

The Canadian Building Projects used these categories and awarded LEED points to forty-two new construction projects across Canada. The points most often awarded, as well as those that are granted the least frequently, were tabulated to determine the most frequently used sustainable building practices. This determined the ranking system based on LEED 2004-2008 scoring criteria. The data was combined with the Davis Langdon knowledgebase. It provided established green building cost information of more than six hundred distinct projects across the United States. In addition, it randomly selected sixty-one LEED seeking projects from this same database to complete and analysis on green feasibility and costs. This provided a ranked dataset for this study of more than one hundred LEED projects using the forty-two projects from the Canadian Building Project and sixty-one from Landon (see Table 2 in appendix).

Results

After comparing the two differing databases, fifteen LEED Point commonalities were identified between the ranking of obtained points in the commercial sector and the perceived importance in the residential sector. There were some overlaps of obtained points in the residential sector which resulted in the ranking of twenty-five being reduced to fifteen obtainable points in LEED. For example; water conserving utilities (dishwashers) and water conserving fixtures on the residential ranking would result in obtainment of Water Efficiency (WE) 3.1 on the LEED scoring system. Table 3 shows the ranking system between the differing construction sectors.

Table 3: Ranking of Obtainable LEED Points

Obtainable LEED Point	Commercial Rank	Residential Rank
EA1.1	3	1
SS2.0	11	14
MR7.0	14	5
SS5.1	13	2
MR4.1	9	3
WE3.1	1	4
MR6.0	4.5	6
SS1.0	2	9
EQ4.2	16	7
SS5.2	10	8
EQ4.1	6	10
SS1.0	4.5	11
EQ5.0	7	12
EQ2.0	8	13
WE2.0	15	15

Table 4: Spearman Correlation breakdown

Obtainable LEED Point	Commercial Rank	Residential Rank	Difference	Difference Squared
EA1.1	3	1	-2	4
SS2.0	11	14	3	9
MR7.0	14	5	-9	81
SS5.1	13	2	-11	121
MR4.1	9	3	-6	36
WE3.1	1	4	3	9
MR6.0	4.5	6	1.5	2.25
SS1.0	2	9	7	49
EQ4.2	16	7	-9	81
SS5.2	10	8	-2	4
EQ4.1	6	10	4	16
SS1.0	4.5	11	6.5	42.25
EQ5.0	7	12	5	25
EQ2.0	8	13	5	25
WE2.0	15	15	0	0
		Sum of Diff Squared =		**504.5**
	rs = 1-6(504.5)/15(225-1)			
	rs = 1-3027/3360			
	rs = 1-.9009			
	rs = .0991			

Testing the significance of the relationship at the 0.05 alpha level for an *n*=15 resulted in an *rs* = 0.0991. For there to be a significant relationship between the commercial and residential sector, an *rs* value of 0.443 would have had to been obtained. Table 4 provides the results.

When comparing the Commercial sector to the Residential construction industry it can be inferred that there are true differences between the two markets. It indicates while the commercial sector is driven by owner's quantitative profitability analyzing life cycle costs to drive decision making, the residential sector remains driven by the "feel good" personal effects a home has on its buyer.

Conclusions and Recommendations for Future Study

The research presented in the paper uses a variety of data points from historical studies and surveys regarding sustainable building practices. The statistical analysis used for the study is a single look at the influence of Commercial LEED and its ability to influence the residential builder. While the study has limitations it does advance the research of the different building sectors. A statistically significant correlation was not found that could identify commercial green practices that are influential to the residential sector. It can be inferred that any residential "green movement" or advances need to be tailored specifically to the residential market. Future research needs to begin and stay in the residential sector with care not to rely on commercial best practices as viable residential alternatives. It is apparent, to be successful in developing a green building, each sector of construction needs to be analyzed and reviewed individually. This will remain true when preparing future builders, marketing to prospective clients, and establishing codes and regulations for the built environment. While the fundamental processes of building may be similar for the residential and commercial sectors, the driving force that has surrounded the successes remains different in the green environment just as they have for the last hundred years of building methods.

For residential builders, the results of this research should be a call of involvement. The success found in the commercial sector as mentioned above can be attributed to government incentives or mandates, building life-cycle analysis, and educating the workforce. The government influence on the commercial market was not a top-down approach, but a strategic advocacy effort driven by local and state commercial non-profit organizations such as the Associated General Contractors. The commercial builders identified an opportunity for growth and improvement in the marketplace, and they joined together advocating for change. The residential companies have a large non-profit voice in the National Association of Home Builders. Residential market leaders must recognize the influence of increased membership and organized participation.

Technology and performance information on the products used to construct the home have never been more accessible. Today's builders can no longer allow the end consumer to choose products or materials that perform inadequately over the life of the home. It is the constructors' responsibility to educate the end user on overall life cycle cost of products and its impact on their investment. The commercial sector has been successfully using this life-cycle analysis in financial decisions for decades; it is now time for the residential builder to do the same.

Finally, the quality of the workforce the residential builder chooses to use on the building site must become a priority. The technology and sophistication of today's products do not begin with the end-user, but with the installation of the product itself. This "jack-of-all-trades" individual that can perform multiple tasks is giving way to a more educated specialized workforce. The ability to manage this increase in workforce cannot be overlooked. The next decades in the residential construction sector are going to be more competitive than ever. It is the residential builder that recognizes these industry changes and opportunities that will be able to compete and survive in the marketplace.
As the residential market begins to recover and builders look for competitive advantages, this study provides insight into the uniqueness of the sector in which the residential builder resides. The builder will not find insight into successful green building practices from the commercial sector; rather they must remain in their local area to make decisions on what the end-user will want.

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Appendix

Table 1 identifies the percentage of green practices that residential builders believe are effective and thus most willing to incorporate into their building. (See Table 1)

Table 1: Residential Green SmartMarket Report: McGraw Hill ranking

McGraw Hill Construction Survey Results		
Rank	**Residential View of Builders**	**%**
1	EE: High Efficiency HVAC System	92
2	EE: Low E Glass Windows	90
3	IAQ: High Efficiency HVAC Systems	90
4	EE: Energy Efficient Appliances	88
5	MR: High Performance Engineered Wood	84
6	GS: Site Disruption Minimization	82
7	WC: Storm Water Mitigation	75
8	WC: Water Conserving Utilities	75
9	WC: Water Conserving Fixtures	73
10	IAQ: Formaldehyde-Free Finishes	72
11	GS: Recycled Material Usage	68
12	MR: Alternatives to Wood	68
13	GS: Open Space Preservation	66
14	IAQ: Minimum Off-Gassing	65
15	IAQ: Low VOC Paint	65

Table 2: Determining rank by frequently used sustainable building practice combined ranking/listing using Silva and Ruwanpura data with the Langdon knowledgebase.

		Certified			Silver			Gold/Platinum			Total
RANK	**LEED Point**	**Silva**	**Langdon**	**Mean**	**Silva**	**Langdon**	**Mean**	**Silva**	**Langdon**	**Mean**	**Mean**
1	ID2.0	100	98	99	100	100	100	100	100	100	99.86
2	MR5.1	100	97	98.5	100	100	100	95	100	97.5	98.71

RANK	LEED Point	Certified Silva	Certified Langdon	Certified Mean	Silver Silva	Silver Langdon	Silver Mean	Gold/Platinum Silva	Gold/Platinum Langdon	Gold/Platinum Mean	Total Mean
3	WE3.1	100	100	100	93	94	97.4	100	100	100	97.77
4	EQ4.3	88	92	90	87	100	93.5	95	100	97.5	94.71
5	MR4.1	75	96	85.5	100	95	97.5	89	100	94.5	94.50
6	MR2.1	88	100	94	87	100	93.5	89	100	94.5	94.00
7	EA1.1	75	93	84	93	94	93.5	100	92	96	93.21
8	WE1.1	88	83	85.5	93	94	88.7	100	83	91.5	90.81
9	EQ4.2	75	95	85	87	94	90.5	84	100	92	90.36
10	ID1.1	100	68	84	100	81	90.5	100	83	91.5	90.00
11	Ss4.2	100	81	90.5	93	82	87.5	100	84	92	89.86
12	EQ4.1	88	100	94	73	100	86.5	79	100	89.5	88.86
13	SS1.0	88	84	86	87	93	90	89	84	86.5	87.93
14	EQ7.1	50	78	64	67	94	80.5	79	100	89.5	82.00
15	EQ3.1	63	95	79	60	94	77	74	100	87	81.57
16	EA1.2	38	55	46.5	73	88	80.5	100	83	91.5	80.36
17	MR2.2	38	73	55.5	67	70	68.5	84	100	92	76.71
18	SS4.1	63	75	69	67	69	68	74	100	87	76.29
19	SS8.0	50	62	56	67	94	80.5	63	84	73.5	74.00
20	ID1.2	100	31	65.5	93	44	68.5	95	68	81.5	73.64
21	EQ8.2	63	52	57.5	80	62	71	84	68	76	71.21
22	EQ3.2	38	90	64	33	94	63.5	58	100	79	70.21
23	WE3.2	100	10	55	80	18	52.6	100	83	91.5	68.59
24	EQ4.4	13	42	27.5	60	75	67.5	63	100	81.5	67.79
25	EQ5.0	75	65	70	67	70	68.5	63	68	65.5	67.43
26	EQ1.0	50	53	51.5	53	70	61.5	68	83	75.5	66.07
27	SS7.1	13	62	37.5	67	82	74.5	68	66	67	66.00
28	EA3.0	25	45	35	47	88	67.5	58	83	70.5	64.14
29	EA4.0	38	58	48	27	75	51	74	83	78.5	62.36
30	MR5.2	75	3	39	93	12	52.5	89	68	78.5	61.71
31	WE1.2	63	17	40	80	31	46.2	79	67	73	59.46
32	ID1.3	88	9	48.5	67	25	46	95	50	72.5	57.71
33	EQ8.1	13	34	23.5	73	56	64.5	47	68	57.5	55.64
34	MR4.2	50	17	33.5	87	26	56.5	53	68	60.5	54.93
35	SS6.2	38	49	43.5	27	63	45	68	66	67	54.21
36	EQ7.2	25	25	25	47	50	48.5	53	83	68	53.50
37	SS7.2	25	43	34	40	64	52	37	84	60.5	53.07
38	ss4.4	38	58	48	60	38	49	79	35	57	52.29
39	SS6.1	13	35	24	33	63	48	63	66	64.5	51.64
40	EA1.3	13	8	10.5	47	44	45.5	84	58	71	51.43
41	Ss5.2	0	35	17.5	60	70	65	53	35	44	49.21
42	EQ2.0	13	17	15	40	50	45	37	68	52.5	43.93
43	EQ6.1	13	25	19	27	31	29	37	68	52.5	37.64

		Certified			Silver			Gold/Platinum			Total
RANK	LEED Point	Silva	Langdon	Mean	Silva	Langdon	Mean	Silva	Langdon	Mean	Mean
44	ID1.4	25	0	12.5	53	12	32.5	79	17	48	36.29
45	WE2.0	25	5	15	13	26	16.8	68	50	59	35.40
46	SS5.1	0	37	18.5	20	44	32	47	35	41	33.93
47	EA5.0	0	25	12.5	13	38	25.5	11	67	39	29.43
48	EQ6.2	25	6	15.5	33	7	20	26	50	38	27.07
49	MR7.0	13	32	22.5	7	44	25.5	5	50	27.5	25.93
50	SS2.0	13	9	11	20	32	26	26	34	30	25.57
51	EA6.0	50	9	29.5	40	0	20	37	17	27	24.36
52	EA2.1	0	11	5.5	0	26	13	21	50	35.5	21.57
53	EA1.4	13	0	6.5	7	4	5.5	58	17	37.5	19.36
54	SS4.3	0	11	5.5	20	12	16	32	17	24.5	18.14
55	EA2.2	0	9	4.5	0	26	13	16	35	25.5	17.14
56	MR3.1	13	3	8	7	6	6.5	21	35	28	15.93
57	MR6.0	0	9	4.5	7	6	6.5	5	50	27.5	15.21
58	SS3.0	25	3	14	20	0	10	37	0	18.5	14.21
59	EA2.3	0	0	0	0	8	4	11	35	23	11.57
60	EA1.5	13	0	6.5	0	0	0	26	17	21.5	10.14
61	MR8.0	0	0	0	13	0	6.5	16	0	8	6.21
62	MR1.1	13	6	9.5	0	7	3.5	5	0	2.5	3.93
63	MR3.2	13	0	6.5	0	0	0	11	0	5.5	3.29
64	MR1.2	13	3	8	0	0	0	0	0	0	1.14
65	MR1.3	0	0	0	0	0	0	0	0	0	0.00