SILVER AND GOLD LEED COMMERCIAL INTERIORS: CERTIFIED PROJECTS

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ABSTRACT

Leadership in Energy and Environmental Design Commercial Interiors (LEED-CI) is more relevant to interior design, which, according to the sharing layer concept, differs from exterior design (which is usually evaluated with the LEED New Construction sub-scheme). LEED-CI requires separate empirical analyses of LEED-CI certified buildings to further improve this sub-scheme. Therefore, in this study, Silver and Gold projects certified under LEED-CI-2009 in 14 US states were considered. Three project performance analyses, (i) certification, (ii) category, and (iii) cross-certification, were studied. The following results were revealed: (i) the range of the medians for Silver- and Gold-certified projects were 51–57 pts and 62–71 pts, respectively; (ii) in both Silver- and Gold-certified projects, Sustainable Sites (SS), Water Efficiency (WE), and Innovation in Design (ID) were the best-performing; Energy and Atmosphere (EA) and Indoor Environmental Quality (EQ) were intermediate-performing; and Material and Resources (MR) was the worst-performing categories; and (iii) in Silver-Gold cross-certification, category-focused (in 10 of 14 states) and category-unfocused (in four of 14 states) strategies were determined; in the category-focused strategy, the highest popular category was EA; the intermediate popular categories were WE, MR, and ID; and the lowest popular category was SS. Pooling all projects and all states into one frame can lead to the obscurement of the actual LEED-CI-2009 strategy(ies) in the transition from Silver to Gold certification in the US.

KEYWORDS

LEED-CI 2009, rating system, certified projects, sampling frame, primary sampling units, evaluation sampling units

INTRODUCTION

Currently, green certification schemes have shaped sustainable buildings around the world (Suzer 2015). Among several other mature schemes, such as the BRE Environmental Assessment Method (BREEAM), Sustainable Building Tool (SBTool), Comprehensive Assessment System

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for Built Environment Efficiency (CASBEE) and Green Star, the Leadership in Energy and Environmental Design (LEED) rating system is widely applied both in the US and globally (Suzer 2015; Ma and Cheng 2016; Wu et al. 2017).

LEED has four levels of certification: Certified (40–49 pts), Silver (50–60 pts), Gold (60–79 pts), and Platinum (80–110 pts). LEED certification can be performed under any appropriate sub-scheme, such as LEED for New Construction and Major Renovations (LEED-NC), Existing Buildings: Operations & Maintenance (LEED-EB), Commercial Interiors (LEED-CI), Core and Shell Development (LEED-C&S), Retail, Schools, Homes, Neighborhood Development, and Healthcare. LEED sub-schemes suggest the evaluation of building "greenness" through seven categories: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), Indoor Environmental Quality (EQ), Innovation and Design Process (ID), and Regional Priority (RP).

LEED sub-schemes constantly change to incorporate new improved versions (Wu et al. 2017). These improvements rely on two sources of research: (i) rating sub-scheme analyses (Yu and Kim 2011; Chen et al. 2015; Pushkar and Shaviv 2016; Illankoon et al. 2017) and (ii) surveys of certified projects (Ma and Cheng 2016; Wu et al. 2016; Wu et al. 2017; Pushkar and Verbitsky 2018).

Surveys of certified projects are important analyses that can suggest further improvements for the upcoming versions of the rating sub-schemes (Wu et al. 2017). Among all available LEED sub-schemes, mainly LEED-NC certified projects have been comprehensively studied (Wu et al. 2016; Ma and Cheng 2016; Wu et al. 2017; Pushkar and Verbitsky 2018). Wu et al. (2016) studied 5,340 LEED-NC v2.2-certified projects between 2007 and 2015 worldwide; Ma and Cheng (2016) analyzed 1,000 LEED-NC 2009-certified projects throughout the US; Wu et al. (2017) considered 3,416 LEED-NC 2009-certified projects up to July 2015 worldwide; and Pushkar and Verbitsky (2018) studied 920 LEED-NC 2009-certified projects through 2016 in 10 US states.

Such intensive research has resulted in well-grounded conclusions regarding the LEED-NC certification practice in terms of the (i) certification performance (e.g., the total number of points received by a project in all LEED-NC categories for a certain level of certification, such as the Silver certification performance), (ii) category performance (e.g., the total number of points received by a project in the individual category, for example, in SS for a certain level of certification, such as Silver SS category performance), and cross-certification performance (the difference between the total number of points per category, for example, SS for any two adjacent certification levels, Silver-to-Gold SS performance) (e.g., Pushkar and Verbitsky 2018).

In particular, (i) low Silver (53–55 pts) and Gold (62–64 pts); (ii) high SS, EQ, and ID categories performances (60–70% of the total credits in each of these categories are awarded to all green building projects); and (iii) high EA Silver-to-Gold cross-certification performances (12-to-18 pts) were reported (Wu et al. 2016; Wu et al. 2017; Pushkar and Verbitsky 2018). However, these empirical results cannot be determined as appropriate for projects certified with other LEED sub-schemes because of the inherent differences among these sub-schemes.

Based on the shearing layer concept, building design can be divided into exterior design and interior design (Brand 1994). For example, interior design is associated with shorter timescale building layers, such as services, space plan, and stuff (timescale: 20 years–monthly), while exterior design is associated with long timescale building layers, such as the site, structure, and skin (timescale: eternal–20 years). Consequently, LEED-CI is related to interior designs, whereas LEED-NC is related to exterior designs.

Thus, despite the similar distribution in the maximum allowed points among SS, WE, EA, MR, EQ, ID, and RP categories in the LEED-CI 2009 and LEED-NC 2009 sub-schemes (Table 1), in some categories, LEED-CI 2009 (interior design) and LEED-NC 2009 (exterior design) emphasize different issues. For example, SS has less influence in LEED-CI (21 pts) than in LEED-NC (26 pts), while EA has more emphasis in LEED-CI (37 pts) than in LEED-NC (35 pts) (LEED-CI 2009; LEED-NC 2009). Additionally, there are differences in some inherent credits between LEED-CI and LEED-NC. For example, the EA category in LEED-CI 2009 includes four separate sub-credits for EAc1 Optimize Energy Performance (Eac1.1 Lighting Power, Eac1.2 Lighting Control, Eac1.3 HVAC, and Eac1.4 Equipment and Appliances) (LEED-CI 2009), whereas the EA category in LEED-NC 2009 includes only the EAc1 Optimize Energy Performance credit, which should cover all relevant energy issues, lighting, HVAC, equipment, and appliances combined (LEED-NC 2009).

Therefore, despite well-documented survey analyses of the LEED-NC sub-scheme (Fuerst 2009; Ma and Cheng 2016; Wu et al. 2016; Wu et al. 2017; Pushkar and Verbitsky 2018), there is still a need for survey analysis of the LEED-CI sub-scheme.

Three research questions are addressed in this study: (i) Is there any difference between the Silver and Gold performance? (ii) Is there any difference in the category strategies between Silver and Gold? (iii) Are there well-defined category strategies that allow the transition from Silver to Gold? To answer these questions, the performances in terms of the (i) certification, (ii) category, and (iii) cross-certification of LEED-CI 2009 Silver- and Gold-certified projects were analyzed. Only US states with a suitable and balanced sample size of observational data were considered in this research. The results of the trends in these three performance analyses can help LEED-CI rating system experts further improve the LEED certification process.

RESEARCH METHODOLOGY

Problem of large sample size and low P-value in data of LEED projects

Wu et al. (2017) considered 3,416 LEED-NC 2009-certified projects up to July 2015 worldwide (a large sampling size was used). This study found (i) low certification performance and (ii) high performance in the ID category and low performance in the EA and MR categories; additionally, (iii) for the cross-certification performance (Wu et al. 2017 Table 7, p 375), the significant difference (P-value) and absolute effect size (mean difference increase [mdi]) were

TABLE 1. LEED-NCv3 vs LEED-CIv3: Categories with allocated points.

Category	LEED-CI 2009	LEED-NC 2009
Sustainable Sites	21	26
Water Efficiency	11	10
Energy and Atmosphere	37	35
Materials and Resources	14	14
Indoor Environmental Quality	17	15
Innovation in Design	6	6
Regional Priority	4	4
Total	110	110

used to draw conclusions. For example, Wu et al. (2017) revealed that all six categories (namely, SS, WE, EA, MR, EQ, and IO) exhibit a significant difference between the Silver and Gold projects (P = 0.000). However, Wu et al. (2017) emphasized that for a building to achieve the Gold level over the Silver level, the following three categories EA (mdi = 5.46 points), SS (mdi = 2.57 points) and WE (mdi = 0.84 points) had mainly been used. Therefore, it should be noted that the absolute effect size does not consider the variability in scores, in that not every subject achieved the average outcome (Sullivan and Feinn 2012).

The problem of interpretation of highly statistically significance (P = 0.000) with large sample size, as demonstrated by Wu et al. (Wu et al. 2017), occurs when practical significance is based solely on statistical significance (P value) "with ignoring magnitude of association," commonly referred to as the standardized effect size (George et al. 2016). In this context, the non-parametric Cliff's Delta (δ) (standardized effect size) should be used (Cliff 1993). It should be noted that "with a sufficiently large sample, a statistical test will almost always demonstrate a significant difference, unless there is no effect whatsoever, that is, when the effect size is exactly zero; yet very small differences, even if significant, are often meaningless." (Sullivan and Feinn 2012). By contrast, it is often seen that the effect sizes are resistant to the influence of sample size and thus provide a truer measure of the magnitude of effect among variables (Ferguson 2009).

An additional problem with having a large sample size is that data can be pooled from different "natural" clusters, for example, from different states throughout the US (Fuerst 2009; Ma and Cheng 2016) or worldwide (Wu et al. 2016; Wu et al. 2017). However, it is a well-known fact that there are differences in the green and/or energy building codes among states (Sun et al. 2016), such as the implementation of ASHRAE 90.1 (Energy Standard for Buildings Except Low-Rise Residential Buildings) and the International Energy Conservation Code (IECC) under state regulations in the US; therefore, different versions of the IECC and/or ASHRAE 90.1 standard are adopted in different US states (Sun et al. 2016).

Consequently, total project pooling can consider the influence of some uncontrolled treatment factors, such as the ASHRAE 90.1 version, for example, which may misrepresent the results (Pushkar and Verbitsky 2018). If significance tests are to be applied to this pooled data, they can lead to "artificially inflated degrees of freedom, giving the illusion of having a more powerful test than the data support" (Picquelle and Mier 2011). This situation is identified as an example of sacrificial pseudoreplication (Hurlbert 1984; 2009; 2013).

Recently, separate analyses of Silver and Gold LEED-NC 2009 projects through 2016 for each of the 10 US states were performed (Pushkar and Verbitsky 2018). In their study, a small or medium sample size was used. The data revealed (i) low certification performance and (ii) high performance in the SS and ID categories and low performance in the EA and MR categories; in addition, (iii) for the cross-certification performance, three different strategies were presented for moving projects from Silver to Gold, namely, EA-emphasized, non-EA emphasized, integrated (all categories contributed to cross-certification) (Pushkar and Verbitsky 2018).

Data collection

A total of 2,289 LEED-CI 2009-certified projects in the US were collected from the United States Green Building Council (USGBC) up through November 2017. The projects were sorted by four certification levels: Certified, Silver, Gold, and Platinum. Only the two most popular certification levels, Silver and Gold, were selected for the analysis.

The LEED projects contain ordinal scale data, and therefore, non-parametric statistical tests should be used. States with 20 or more LEED projects for Silver (group 1) and for Gold (group 2) (sample sizes, $n_1 = n_2 \geq 20$) were selected. Then, in each of the selected states, equal sample sizes for Silver- ($n_1 = 20$) and Gold- ($n_2 = 20$) certified projects were randomly selected. In total, 14 states with a project sample size $n_1 = n_2 = 20$ were selected.

Then, the USGBC scorecards of the selected projects were downloaded from the USGBC LEED Commercial Interiors Projects Directory, and data concerning the awarded points in the SS, WE, EA, MR, IEQ, ID, and RP categories were collected. Eventually, the RP points were redistributed among the relevant main categories: SS, WE, EA, MR, and EQ.

Design of the study

The design of the study contains three sets: (i) design of the certification performance study; (ii) design of the category performance study; and (iii) design of the cross-certification performance study. Each of the three designs is described in detail below.

Design of the certification performance study. The difference between the median of the averaged six LEED-CI 2009 categories from 14 states of either Silver or Gold certification projects and the lower boundary of either the Silver certification (50 pts) or the Gold certification (60 pts) with sample sizes $n_1 = n_2 = 14$ were evaluated. In this context, 14 states were defined as the primary sampling units (i.e., statistically independent units). Each of the 14 primary sampling units contained two sub-units: Silver and Gold projects. Each sub-unit contained 20 projects, i.e., evaluation units. The median of 20 Silver projects and the median of 20 Gold projects can be defined as two statistically independent sub-units (i.e., two independent groups). Therefore, 14 primary sampling units were split into two independent groups: Silver (group 1) and Gold (group 2) projects with a sample size $n_1 = n_2 = 14$. This study design is defined as a single-unit design structure (Hurlbert 2013).

Design of the category performance study. Paired comparisons of the six categories of LEED-CI 2009 from 14 states for Silver and Gold projects (i.e., sample sizes, $n_1 = n_2 = 14$) were evaluated using credit achievement degrees (CADs). CADs were calculated using the following ratio (Wu et al. 2017, p. 372):

$$CAD = \frac{\text{points of layer obtained}}{\text{total points of the layer}} \cdot 100\%$$

The CAD scale was also converted to the decile range to evaluate the quality of the data.

Design of the cross-certification performance study. The difference between the Silver projects (group 1) and Gold projects (group 2) from the same state with sample sizes $n_1 = n_2 = 20$ was compared for each of the 14 states. In this context, 20 Silver and 20 Gold projects were defined as the primary sampling units (i.e., statistically independent units), while each of 14 states was defined as the sampling frame i.e., the collection of all primary sampling units (Picquelle and Mier 2011). This study design can be defined as a single-unit design structure (Hurlbert 2013, Pushkar et al. 2014).

Statistical analysis

Descriptive statistics. LEED-CI 2009 data were presented as the median ± interquartile range (IQR, 25th–75th percentile). The CAD and decile ranges were used, as described previously (Pushkar and Verbitsky 2018).

Inferential statistics. In the current study, for standard types of significance assessment, the hybrid of the Paleo–Fisherian and Neyman–Pearsonian paradigms [i.e., null hypothesis significance tests (NHST)] are replaced by a neo-Fisherian assessment, as recommended by Hurlbert and Lombardi (2009; 2012). The neo-Fisherian paradigm (1) does not fix α, (2) does not describe P-values as 'significant' or 'nonsignificant', (3) does not accept null hypotheses based on high P-values but only suspends judgment, (4) interprets significance tests according to "three-valued logic," and (5) presents effect size information in conjunction with significance tests. Analyses conducted under this paradigm are termed neo-Fisherian significance assessments (NFSAs) (Hurlbert and Lombardi, 2009). NFSAs are used to interpret the signs and magnitudes of the statistical effects (Hurlbert and Lombardi 2009). In addition, Hurlbert and Lombardi (2009) cited the suggestion of Gotelli and Ellison (2004), noting that "in many cases, it may be more important to report the exact P-value and let the readers decide for themselves how important the results are."

A non-parametric two-tailed Wilcoxon Mann–Whitney (WMW) test with normal approximation was applied to determine the significant difference between two distributions (Mann and Whitney 1947). Non-parametric Cliff's δ was applied to measure the magnitude of the difference of two distributions (Cliff 1993).

Based on NFSAs, precise P-values were evaluated and presented according to the three-valued logic as follows: "it seems to be positive" (i.e., there seems to be a difference between group 1 and group 2), "it seems to be negative" (i.e., there does not seem to be a difference between groups 1 and 2), and "judgment is suspended" regarding the difference between groups 1 and 2 (Hurlbert and Lombardi 2009; 2012).

Cliff's δ (Cliff 1993, p. 495) is expressed as follows:

$$\delta = \#\left(x_1 > x_2\right) - \#\left(x_1 < x_2\right) / \left(n_1 n_2\right)$$

where x_1 and x_2 are scores within groups 1 and 2, respectively; n_1 and n_2 are the sizes of the sample groups, i.e., groups 1 and 2, respectively; and # indicates the number of counts.

Cliff's δ ranges between –1 and +1: positive (+) values indicate that group 1 is larger than group 2, 0 indicates equality or overlap, and negative (–) values indicate that group 2 is larger than group 1 (Cliff 1993).

The effect size is considered (i) negligible if $|\delta| < 0.147$, (ii) small if $0.147 \le |\delta| < 0.33$, (iii) medium if $0.33 \le |\delta| < 0.474$, or (iv) large if $|\delta| \ge 0.474$ (Zhang et al. 2016). According to Cohen (1992 p. 156), "a medium effect is visible to the naked eye of a careful observer. A small effect is noticeably smaller than medium but not so small as to be trivial. A large effect is the same distance above the medium as small is below it." It should be noted that the effect size is not "iron-clad criteria" (Durlak 2009) but only a general rule of thumb that might be followed in the absence of knowledge of the area (Volker 2006).

RESULTS AND DISCUSSION

Preliminary results: setting the most representative projects

In the certification levels, the following number of projects was recognized: Certified—425, Silver—780, Gold—890, and Platinum—194 projects. Thus, under the LEED-CI scheme, Silver and Gold were recognized as the most representative certification levels, at 34% and 39%, respectively. Therefore, the results reveal the popularity of Silver and Gold under other certification schemes, with 33% and 56%, respectively, for LEED-EB (Cheng and Ma 2015) and with 38% and 35%, respectively, for LEED-NC (Wu et al. 2017). As concluded by Sandoval and Prakash (2016), the popularity of Silver and Gold is due to the best cost-benefit ratios, wide range of experience of the building practitioners, and more reasonable time frames associated with these certification levels.

The total number of Silver and Gold projects for each of the US states is presented in Table 2. From the results, 15 representative states, each with more than 20 projects with Silver

TABLE 2. LEED-CI 2009 Silver- and Gold-certified projects (total number) in the US by state, up through November 2017.

State (Two-letter Abbreviations)		Silver	Gold	State (Two-letter Abbreviations)		Silver	Gold
Alabama	AL	2	2	Montana	MT	1	0
Alaska	AK	0	0	Nebraska	NE	2	0
Arizona	AZ	16	6	Nevada	NV	4	3
Arkansas	AR	6	4	New Hampshire	NH	0	0
California	***CA***	***141***	***219***	***New Jersey***	***NJ***	***20***	***25***
Colorado	***CO***	***27***	***22***	New Mexico	NM	6	3
Connecticut	CT	7	7	***New York***	***NY***	***79***	***111***
Delaware	DE	3	0	***North Carolina***	***NC***	***20***	***29***
Florida	***FL***	***38***	***29***	North Dakota	ND	0	0
Georgia	***GA***	***26***	***34***	***Ohio***	***OH***	***32***	***23***
Hawaii	HI	2	0	Oklahoma	OK	2	2
Idaho	ID	2	3	Oregon	OR	7	25
Illinois	***IL***	***47***	***31***	***Pennsylvania***	***PA***	***35***	***37***
Indiana	IN	5	5	Rhode Island	RI	2	4
Iowa	IA	4	3	South Carolina	SC	10	6
Kansas	KS	10	4	South Dakota	SD	2	0
Kentucky	KY	2	2	Tennessee	TN	13	12
Louisiana	LA	4	3	***Texas***	***TX***	***40***	***49***
Maine	ME	0	2	Utah	UT	4	6
Maryland	***MD***	***25***	***26***	Vermont	VT	3	4
Massachusetts	***MA***	***23***	***63***	Virginia	VA	35	32
Michigan	MI	17	9	***Washington***	***WA***	***26***	***22***
Minnesota	MN	9	2	West Virginia	WV	0	0
Mississippi	MS	1	1	Wisconsin	WI	6	9
Missouri	MO	14	10	Wyoming	WY	0	1

Notes: Bold italic font indicates the 14 analyzed states.

and Gold certification, were revealed. However, Virginia was excluded from the analysis due to the absence of scorecard data in this state. Thus, in total, 14 states (CA, CO, FL, GA, IL, MD, MA, NJ, NY, NC, OH, PA, TX, and WA) were selected for the analysis.

The results of (i) the certification performance, (ii) the category performance, and (iii) the cross-certification performance analyses for the 14 selected states (based on the data of 20 randomly selected projects in these states) are presented in the following sub-sections.

Certification performance

The total median of the awarded points in the LEED-CI 2009 categories for Silver- and Gold-certified projects in 14 US states (ranked in descending order) are presented in Figure 1. The total median was calculated as a sum of the median points obtained in the SS, WE, EA, MR, IQ, and ID categories. The dashed lines represent the lower boundaries of the Silver (50 pts) and Gold certifications (60 pts).

The ranges of the total medians for Silver- and Gold-certified projects were 57–51 pts and 71–62 pts, respectively. As shown in Table 3, the delta measurements of the Silver and Gold certifications (the total median points over the lower boundary of the certification: above 50

FIGURE 1. Total median of awarded points in the LEED-CI 2009 categories for Silver- and Gold-certified projects in 14 US states.

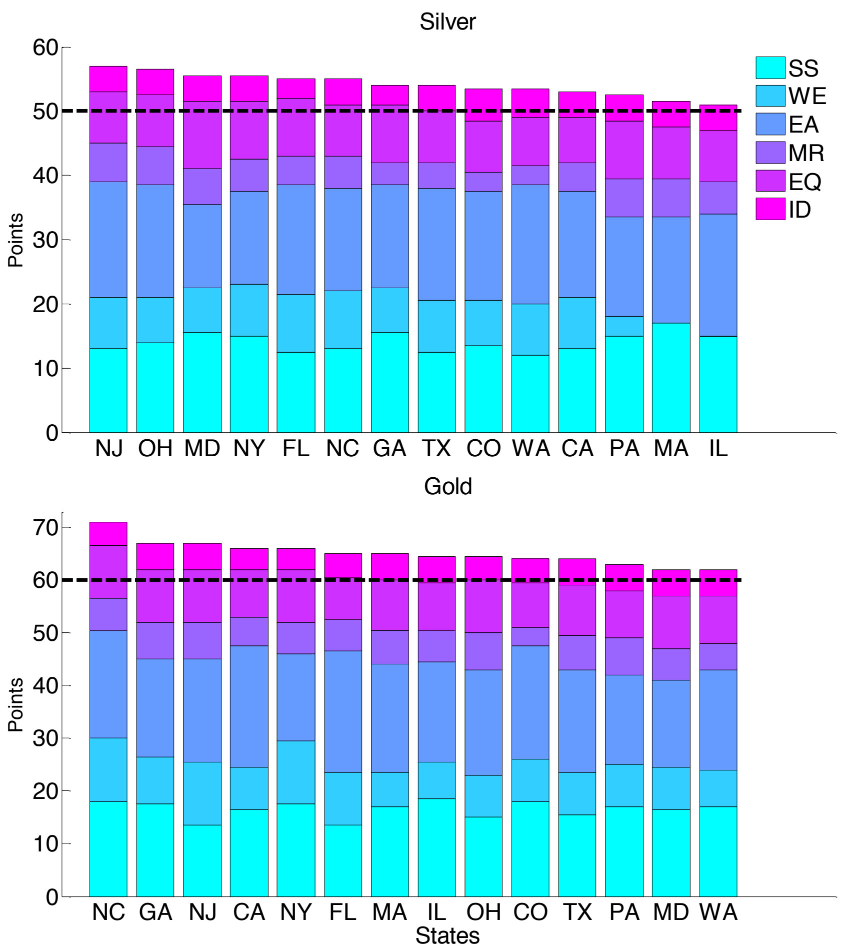

TABLE 3. Median ± interquartile range (IQR, 25th–75th percentile) of the delta measurements of the Silver and Gold certifications (total median points over the lower boundary of the certification: above 50 pts for Silver and above 60 pts for Gold) in 14 US states (sample sizes: $n_1 = n_2 = 14$) in LEED-CI 2009.

Certification levels		z-value	P-value	Cliff's δ	Effect size
Silver	Gold				
4.0±2.5	4.75±2.0	1.011	0.312	–0.230	small

pts for Silver and above 60 pts for Gold) in 14 US states were evaluated. The significant difference in the delta measurements between the Silver (group 1) and Gold (group 2) certifications seems to be negative (P = 0.312), indicating a small effect size (Cliff's δ = –0.230). Thus, in both Silver and Gold certifications, no difference in the certification performance of LEED-CI 2009 was noted. A low certification performance was similarly revealed by other researchers (Wu et al. 2016; Wu et al. 2017; Pushkar and Verbitsky 2018) for a different certification subscheme, i.e., LEED-NC.

Category performance

Silver-certified projects. The median of the awarded points in the SS, WE, EA, MR, EQ, and ID categories and the total points of the assessment area (red dashed line) for the Silver-certified projects in 14 US states (ranked in descending order) are presented in Figure 2. In each of the six categories, the best and worst performing states were recognized. In the SS category, the best-performing and worst-performing states were MA and WA, respectively; in the WE category, they were FL and MA; in the EA category, IL and MD; in the MR category, NJ and CO; in the EQ category, MD and CA; and in the ID category, CO and GA.

In addition, category performance was analyzed by calculating CAD and the decile ranges (Table 4). Decile = 7 was revealed in the SS, WE, and ID categories with CAD medians of 65.47%, 68.18%, and 66.66%, respectively. Decile = 5 was revealed in the EA and EQ categories with CAD medians of 45.27% and 47.05%, respectively. Decile = 4 was revealed in the MR category with a CAD median of 35.71%.

Gold-certified projects. The medians of the awarded points in the SS, WE, EA, MR, EQ, and ID categories and the total points of the assessment area (red dashed line) for the Gold-certified projects in 14 US states (ranked in descending order) are presented in Figure 3. In each of six categories, the different best- and worst-performing states were recognized. In the SS category, the best-performing state was IL and the worst-performing state was NJ; in the WE category, they were, respectively, NC and MA; in the EA category, they were CA and NY; in the MR category, they were GA and CO; in the EQ category, they were NC and FL; and in the ID category, they were GA and NY.

In addition, category performance was analyzed by calculating CAD and the decile ranges (Table 5). Decile = 9 was revealed in the SS and ID categories with CAD medians of 80.95%, 83.33%, respectively. Decile = 8 was revealed in WE category with a CAD median 72.72%. Decile = 6 was revealed in the EA and EQ categories with CAD medians of 52.7% and 54.41%, respectively. Decile = 5 was revealed in the MR category with a CAD median of 42.85%.

FIGURE 2. Medians of the awarded points in the LEED-CI 2009 categories for the Silver-certified projects in 14 US states.

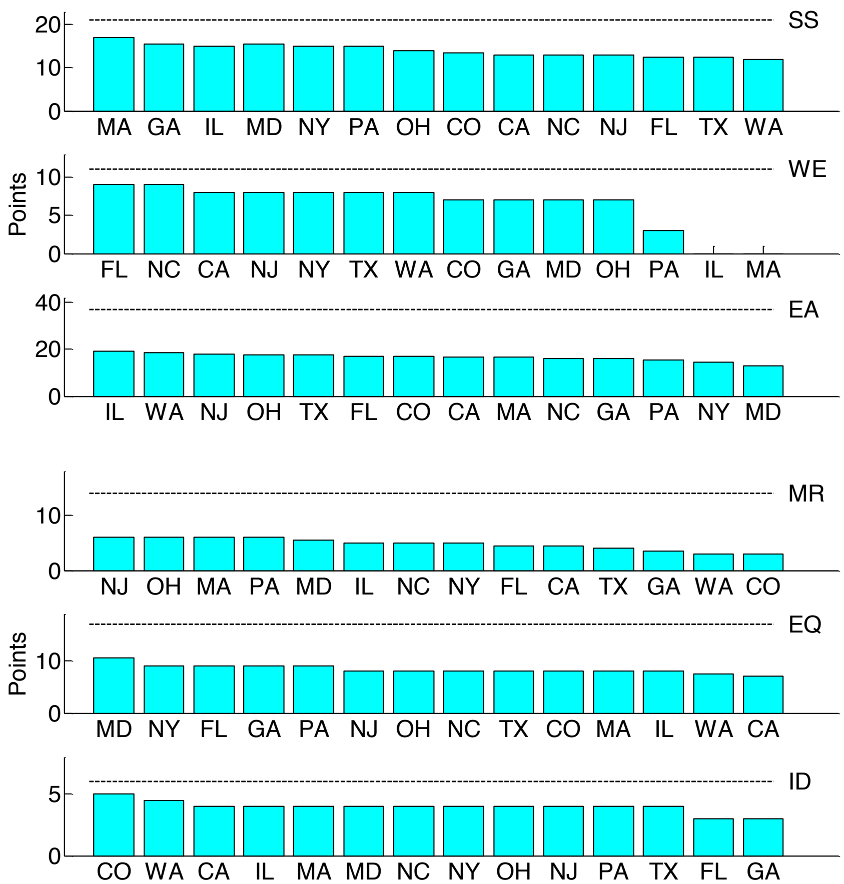

TABLE 4. CAD of LEED-CI 2009 Silver-certified projects in 14 US states.

Category	SS	WE	EA	MR	EQ	ID
Median	65.47	68.18	45.27	35.71	47.05	66.66
IQR	9.52	9.09	4.05	14.28	5.88	0.00
Decile range	7	7	5	4	5	7

Notes: The 14 states are as follows: CA, CO, FL, GA, IL, MD, MA, NJ, NY, NC, OH, PA, TX, and WA. These states were defined as the 14 primary sampling units for each LEED category.

According to the CAD medians of 14 states and the decile range analyses (Table 4 and 5), similar category performances were revealed in the LEED-CI 2009 Silver- and Gold-certified projects. For both certification levels, SS, WE, and ID were the categories with the best performance, MR was the category with the worst performance, and EA and EQ were categories with intermediate performance. These results differ from the results revealed previously for LEED-NC 2009-certified projects (Wu et al. 2017; Pushkar and Verbitsky 2018), which

FIGURE 3. Medians of the awarded points in the LEED-CI 2009 categories for the Gold-certified projects in 14 US states.

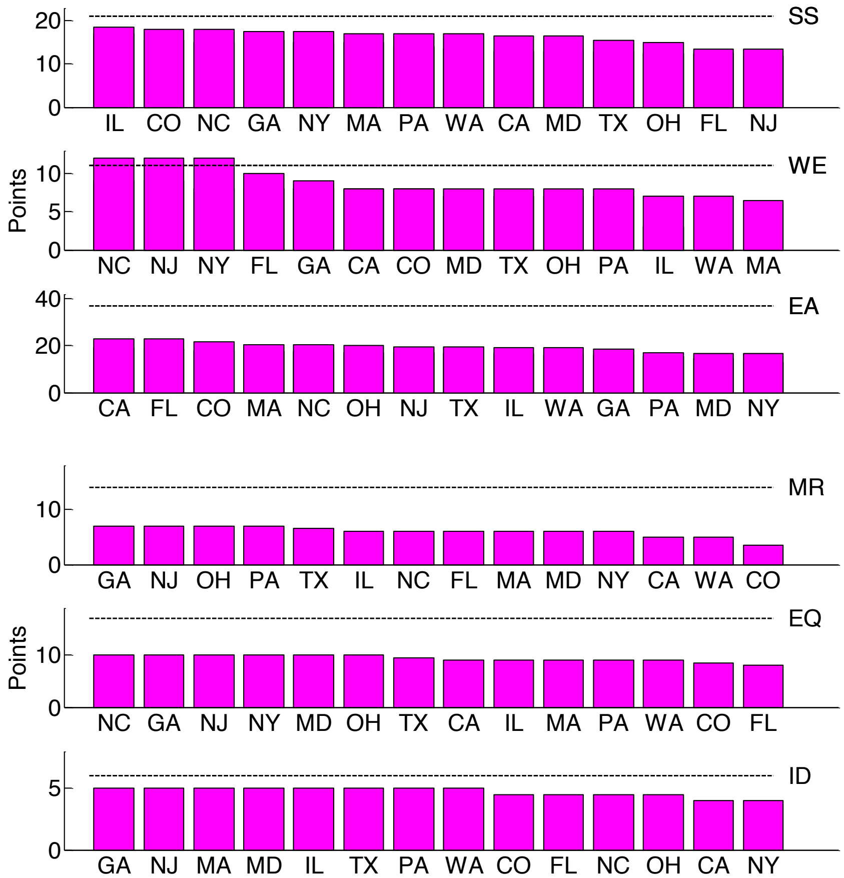

TABLE 5. CAD of Gold LEED-CI 2009 certified projects in 14 US states.

Category	SS	WE	EA	MR	EQ	ID
Median	80.95	72.72	52.7	42.85	54.41	83.33
IQR	9.52	18.18	5.40	7.14	5.88	8.33
Decile range	9	8	6	5	6	9

Notes: The 14 states are as follows: CA, CO, FL, GA, IL, MD, MA, NJ, NY, NC, OH, PA, TX, and WA. These states were defined as 14 primary sampling units for each LEED category.

demonstrated that SS and ID were the best performance categories, while EA and MR were the worst performance categories. The EA category requires a large monetary investment for energy modeling using Optimize Energy Performance (EAc1) and Enhanced Commissioning (EAc2) credits (Wu et al. 2017). Nevertheless, in this study (LEED-CI 2009), the EA category was shown to have intermediate performance, while in LEED-NC-certified projects, a low EA performance was confirmed by other researchers (Wu et al. 2017; Pushkar and Verbitsky 2018).

As seen in the LEED-NC-certified projects, MR remained the worst-performing category in LEED-CI 2009-certified projects. MR is known as a category with hard-to-achieve points owing to the lower likelihood of reducing the consumption of construction materials (Wu et al. 2017).

Cross-certification performance

Analyzing each of 14 states separately

In transiting projects from Silver to Gold, two different strategies were revealed: "category-focused" and "category-unfocused" strategies, as shown in Tables 6.1 and 6.2. The category-focused strategy was demonstrated in 10 of 14 states (Tables 5.1), and the category-unfocused strategy was demonstrated in the other four of 14 states. The criterion to divide the two different groups is decided from the revealed differences in the distributions of the pairs of considered categories for Silver versus Gold, and it indicates the effect sizes.

TABLE 6.1. Category-focused strategy. Silver- and Gold-certified LEED-CI 2009 projects ($n_1 = n_2 = 20$) in 10 US states through November 2017: median ± interquartile range (IQR, 25th–75th percentile) in the six categories.

State	LEED category	Certified projects		P-value	Cliff's Delta, δ	Effect size
		Silver	Gold			
FL	SS	12.5±8.0	13.5±3.5	0.473	–0.135	Negligible
	WE	9.0±4.0	10.0±3.0	0.093	–0.313	Small
	EA	17.0±4.5	23.0±7.5	**0.002**	**–0.563**	**Large**
	MR	4.5±3.0	6.0±2.5	*0.025*	*–0.417*	*Medium*
	EQ	9.0±3.0	8.0±2.5	0.552	–0.113	Negligible
	ID	3.0±2.0	4.5±3.0	*0.022*	*–0.425*	*Medium*
MD	SS	15.5±4.0	16.5±4.5	0.499	–0.127	Negligible
	WE	7.0±5.5	8.0±4.0	0.167	–0.257	Small
	EA	13.0±6.0	16.5±6.5	**0.003**	**–0.545**	**Large**
	MR	5.5±4.0	6.0±2.0	0.646	–0.088	Negligible
	EQ	10.5±4.5	10.0±2.5	0.913	0.022	Small
	ID	4.0±1.5	5.0±2.0	*0.027*	*–0.410*	*Medium*
NC	SS	13.0±4.5	18.0±9.0	0.198	–0.240	Small
	WE	9.0±2.5	12.0±3.0	**0.001**	**–0.600**	**Large**
	EA	16.0±4.5	20.5±11.0	*0.016*	*–0.448*	Medium
	MR	5.0±2.0	6.0±1.0	0.425	–0.150	Small
	EQ	8.0±2.0	10.0±2.0	0.104	–0.302	Small
	ID	4.0±1.0	4.5±3.0	0.081	–0.325	Small
CA	SS	13.0±9.0	16.5±4.0	0.126	–0.285	Small
	WE	8.0±5.0	8.0±5.5	0.337	0.180	Small
	EA	16.5±7.5	23.0±8.5	**0.001**	**–0.600**	**Large**
	MR	4.5±3.5	5.5±2.5	0.080	–0.325	Small
	EQ	7.0±2.0	9.0±4.0	**0.003**	**–0.558**	**Large**
	ID	4.0±1.5	4.0±2.5	0.273	–0.205	Small

TABLE 6.1. *(Continued)*

State	LEED category	Certified projects		P-value	Cliff's Delta, δ	Effect size
		Silver	Gold			
PA	SS	15.0±3.5	17.0±2.0	0.091	−0.315	Small
	WE	3.0±7.0	8.0±5.0	**0.006**	**−0.512**	**Large**
	EA	15.5±6.5	17.0±5.0	0.337	−0.180	Small
	MR	6.0±2.0	7.0±3.0	0.151	−0.267	Small
	EQ	9.0±2.5	9.0±3.0	0.223	−0.228	Small
	ID	4.0±3.0	5.0±1.0	**0.0002**	**−0.680**	**Large**
TX	SS	12.5±9.5	15.5±5.5	0.140	−0.275	Small
	WE	8.0±9.5	8.0±3.0	0.093	−0.313	Small
	EA	17.5±5.0	19.5±6.0	0.130	−0.282	Small
	MR	4.0±2.0	6.5±3.5	**0.003**	**−0.545**	**Large**
	EQ	8.0±3.0	9.5±2.0	*0.034*	*−0.395*	*Medium*
	ID	4.0±2.0	5.0±1.0	**0.010**	**−0.480**	**Large**
WA	**SS**	12.0±8.0	17.0±3.0	**0.0008**	**−0.623**	**Large**
	WE	8.0±5.0	7.0±5.0	0.665	0.083	Negligible
	EA	18.5±3.5	19.0±8.0	0.185	−0.248	Small
	MR	3.0±2.0	5.0±3.0	**0.0003**	**−0.670**	**Large**
	EQ	7.5±3.0	9.0±3.5	0.113	−0.295	Small
	ID	4.5±2.0	5.0±1.0	0.239	−0.220	Small
GA	SS	15.5±4.5	17.5±4.5	0.213	−0.233	Small
	WE	7.0±2.5	9.0±4.5	*0.040*	*−0.382*	*Medium*
	EA	16.0±5.0	18.5±3.5	**0.005**	**−0.518**	**Large**
	MR	3.5±3.0	7.0±2.0	**0.003**	**−0.555**	**Large**
	EQ	9.0±2.0	10.0±2.0	0.126	−0.285	Small
	ID	3.0±2.0	5.0±2.0	**0.001**	**−0.635**	**Large**
MA	SS	17.0±3.5	17.0±3.0	0.570	−0.108	Negligible
	WE	3.0±8.0	9.5±6.0	**0.008**	**−0.547**	**Large**
	EA	16.5±6.0	20.5±5.0	**0.005**	**−0.528**	**Large**
	MR	6.0±3.5	6.5±1.0	0.425	−0.150	Small
	EQ	8.0±1.5	9.5±2.0	**0.007**	**−0.505**	**Large**
	ID	4.0±2.5	5.0±2.5	*0.028*	*−0.407*	*Medium*

Notes: The P-values were evaluated according to the following three-valued logic: bold font—seems to be positive, ordinal font size—seems to be negative, and italic font—judgment is suspended. SS (Sustainable Sites), WE (Water Efficiency), EA (Energy and Atmosphere), MR (Material and Resources), EQ (Indoor Environmental Quality), and ID (Innovation in Design).

TABLE 6.2. Category-unfocused strategy. Silver- and Gold-certified LEED-CI 2009 projects (n_1 = n_2 = 20) in four US states up to November 2017: median ± interquartile range (IQR, 25th–75th percentile) in the six categories.

State	LEED category	Certified projects		P-value	Cliff's Delta, δ	Effect size
		Silver	Gold			
CO	SS	13.5±12.5	18.0±2.0	0.245	−0.218	Small
	WE	7.0±10.0	8.0±6.0	0.151	−0.267	Small
	EA	17.0±8.5	21.5±6.5	*0.047*	*−0.370*	*Medium*
	MR	3.0±3.0	3.5±2.0	0.425	−0.150	Small
	EQ	8.0±3.5	8.5±2.5	0.208	−0.235	Small
	ID	5.0±1.5	4.5±2.5	0.626	0.093	Negligible
NY	SS	15.0±3.0	17.5±4.0	0.123	−0.287	Small
	WE	8.0±6.0	12.0±4.0	*0.040*	*−0.382*	*Medium*
	EA	14.5±6.5	16.5±5.0	*0.062*	*−0.348*	*Medium*
	MR	5.0±3.0	6.0±4.0	0.218	−0.230	Small
	EQ	9.0±4.0	10.0±3.0	0.113	−0.295	Small
	ID	4.0±2.5	4.0±1.0	0.291	−0.198	Small
OH	SS	14.0±7.5	15.0±4.5	0.133	−0.280	Small
	WE	7.0±5.0	8.0±4.0	*0.050*	*−0.365*	*Medium*
	EA	17.5±4.5	20.0±7.0	*0.021*	*−0.427*	*Medium*
	MR	6.0±4.0	7.0±3.0	*0.068*	*−0.340*	*Medium*
	EQ	8.0±2.5	10.0±2.0	*0.029*	*−0.405*	*Medium*
	ID	4.0±2.0	4.5±2.5	0.291	−0.198	Small
IL	SS	15.0±11.0	18.5±2.5	*0.040*	*−0.382*	*Medium*
	WE	0.0±7.5	7.0±8.5	*0.099*	*−0.379*	*Medium*
	EA	19.0±6.5	19.0±4.5	0.379	−0.165	Small
	MR	5.0±3.5	6.0±2.0	0.534	−0.118	Negligible
	EQ	8.0±2.5	9.0±3.0	*0.058*	*−0.353*	*Medium*
	ID	4.0±1.0	5.0±2.0	*0.064*	*−0.345*	*Medium*

Notes: The P-values were evaluated according to the following three-valued logic: bold font—seems to be positive, ordinal font size—seems to be negative, and italic font—judgment is suspended. SS (Sustainable Sites), WE (Water Efficiency), EA (Energy and Atmosphere), MR (Material and Resources), EQ (Indoor Environmental Quality), and ID (Innovation in Design).

For the states in which the difference in distribution between the Silver and Gold project data in one/two/three LEED category(ies) seems to be positive, large effect sizes are involved in the group of category-focused strategy (Table 6.1, bold font categories). For the states in which the difference in distribution between the Silver and Gold project data in one/two/three LEED category(ies) seems to be negative, small effect sizes are involved in the category-unfocused strategy group (Table 6.2, ordinal font size categories). For the states in which the judgment concerning the difference in distribution between the Silver and Gold projects data in one/two/four LEED's category(ies) is suspended, medium effect sizes are also included in the category-unfocused strategy group (Table 6.2, italic font categories).

Category-focused strategy. According to the results obtained in this paper (Table 6.1), for the EA category, a large effect size was evaluated in five of 10 states. The EA category can be defined as the most popular propelling category for moving LEED-CI 2009-certified projects from Silver to Gold (comparing to the Silver projects, the Gold projects obtained a median credit increase of 6.0 in EA). The highest popularity of the EA category was also revealed by other researchers (Wu et al. 2017; Pushkar and Verbitsky 2018) who analyzed Silver-Gold cross-certification performance under the LEED-NC 2009 sub-scheme.

For the WE, MR, and ID categories, large effect sizes were evaluated in three of 10 states, and for the EQ category, large effect sizes were evaluated in two of 10 states (Table 5.1). Thus, the WE, MR, and ID can be defined as intermediate popularity propelling categories for moving LEED-CI 2009-certified projects from Silver to Gold. The results of the EQ category are in agreement with findings of Pushkar and Verbitsky (2018), who analyzed LEED-NC 2009-certified projects and reported that the EQ category was recognized as a propelling category from Silver to Gold in two of the 10 analyzed US states. In the study by Wu et al. (2017), it was shown that the LEED-NC 2009 WE category was also recognized as one of the three main propelling categories (EA, SS, and WE) in Silver-Gold certification.

For the SS category, the large effect size was evaluated in one of 10 states. The SS category can be defined as the least popular propelling category in moving LEED-CI 2009-certified projects from Silver to Gold. By contrast, Wu et al. (2017) found that SS is one of the three main propelling categories (EA, SS, and WE) in moving from LEED-NC 2009-certified Silver to Gold projects. As outlined earlier, there is a difference in the calculation of points of SS between LEED-CI 2009 (21 pts) and LEED-NC 2009 (26 pts). Moreover, in LEED-CI 2009, only three credits—Site Selection, Development Density and Community Connectivity, and Alternative Transportation—are included in the SS category (LEED-CI 2009), while in LEED-NC 2009, in addition to these three credits, another five SS credits—Brownfield Redevelopment, Site Development, Stormwater Design, Heat Island Effect, and Light Pollution Reduction—are also available (LEED-NC 2009). Thus, it seems reasonable that SS was not recognized as a propelling category in LEED-CI 2009-certified projects involving the design and construction of tenant spaces (the present study), whereas it was revealed as an influential propelling category in newly designed and constructed LEED-NC 2009-certified projects (Wu et al. 2017; Pushkar and Verbitsky 2018).

Category-unfocused strategy. In four of the total 14 states, the category-unfocused strategy for LEED-CI 2009 Silver-Gold cross-certification was revealed (Table 6.2). This means that, in general, all categories were involved in this cross-certification performance. Nevertheless, it should be noted that, for the EA and WE categories, medium effect sizes were evaluated in three of four states, thereby designating them as the intermediate popular propelling categories, while for the SS, MR, EQ, and ID categories, small and negligible effect sizes were evaluated in one and two out of four states, respectively. These can be defined as the less popular propelling categories. In general, these results are similar to the results revealed in the category-focused strategy group, confirming that EA is still the most popular propelling category in Silver and Gold performances in most of the analyzed states.

Simultaneous analysis of 14 states. In the pooling of 14 states × 20 projects, the differences in the distribution in the SS, WE, MR, and EQ categories for Silver vs Gold seem to be negative (6.3e-08 ≥ P ≥ 2.0e-09), indicating small effect sizes (–0.230 ≥ Cliff's $\delta \geq -0.294$) (Table 7). It should be noted that one of the statistical errors is a false large sample size (Hurlbert and Lombardi, 2009), as Hurlbert and Lombardi (2009) allegorically noted: "it lurks quietly in the darkness, waiting for researchers to pass by who are too focused on obtaining adequate sample sizes. If sample sizes are too large, one may be 'in danger' of getting very low p-values and establishing the sign and magnitude of even small effects with too much confidence." Consequently, in this context, the NFSA paradigm must be used (Hurlbert and Lombardi, 2009). The judgments concerning the differences in distribution of the EA and ID categories for Silver versus Gold are suspended (P = 5.0e-15 and P = 1.0e-12, respectively) (Table 7), indicating medium effect sizes (Cliff's δ = –0.382 and Cliff's δ = –0.347, respectively). Thus, when all the states were pooled together, different results were revealed, and no category-focused strategy was found. This means that the results reported by the researchers who used the approach of pooling all the analyzed data across the US states or worldwide (Fuerst 2009; Ma and Cheng 2016; Wu et al. 2016; Wu et al. 2017) may not reflect the actual situations of LEED-certified projects.

CONCLUSIONS

In this study, Silver and Gold LEED-CI 2009-certified projects in 14 US states were analyzed. Three performances, namely, (i) certification, (ii) category, and (iii) cross-certification, were evaluated. As a result, the following conclusions were obtained.

TABLE 7. Category-unfocused strategy. Silver- and Gold-certified LEED-CI 2009 projects (n_1 = n_2 = 280) in 14 US states up to November 2017: median ± interquartile range (IQR, 25th–75th percentile) in the six categories.

State	LEED category	Certified projects		P-value	Cliff's Delta, δ	Effect size
		Silver	Gold			
Pooling of 14 US states	SS	14.0±5.0	17.0±5.0	0.000000063	–0.264	Small
	WE	8.0±9.0	9.0±6.0	0.000000013	–0.278	Small
	EA	17.0±6.0	20.0±7.0	*0.000000000000005*	*–0.382*	*Medium*
	MR	5.0±3.0	6.0±2.0	0.000000004	–0.287	Small
	EQ	8.0±3.0	9.0±3.0	0.000000002	–0.294	Small
	ID	4.0±2.0	5.0±2.0	*0.000000000001*	*–0.347*	*Medium*

Certification performance. The delta medians of the delta measurements of the Silver and Gold certifications (the total median points over the lower boundary of the certification: above 50 pts for Silver and above 60 pts for Gold) in 14 US states were 1–7 pts and 2–11 pts for Silver and Gold, respectively. Thus, no difference between the Silver and Gold performances was revealed.

Category performance. For both the Silver- and Gold-certified projects, the same category strategies were used; in particular, SS, WE, and ID were the best-performing categories, MR was the worst-performing category, and EA and EQ were categories with intermediate performances.

Cross-certification performance. Two different strategies for moving LEED-CI 2009 from Silver to Gold were recognized: (i) category-focused and (ii) category-unfocused. The category-focused strategy was revealed in the 10 studied states, while the category-unfocused strategy was revealed in only four states. This means that in most of the studied states, a well-determined strategy was implemented by design teams towards Silver–Gold cross-certification. In this respect, in category-focused states, the EA propelling category was selected as the most popular, with WE, MR and ID as intermediate popularity categories, and SS as the lowest popularity category. Thus, using the single-unit design structure, i.e., the comparison of two unpaired groups of Silver vs Gold projects in the same state, allows the determination of these aforementioned category-focused strategies of certified LEED-CI 2009 projects for the transition from Silver to Gold in the US. By contrast, pooling all Silver projects from all states versus pooling all Gold projects from all states can lead to obscuring the real strategy of LEED-CI 2009 for the transition from Silver to Gold certification in the US.

LIMITATIONS

In this study only one sub-scheme, i.e., LEED-CI was analyzed, and other widely used certification sub-schemes, such as LEED-C&S and LEED-EB, were omitted from the analysis. In this respect, LEED-C&S sub-scheme is remarkably similar to the LEED-NC sub-scheme, for which the certification performance has already been documented in existing literature. However, LEED-EB is a different sub-scheme that may need to be discussed in further LEED empirical research.

In addition, a limited number of US states (14 of 50 states) were analyzed in this study. This is because only in these 14 states were sufficient sample sizes of certified projects revealed in the USGBC project directory.

CONTRIBUTIONS

Additional empirical evidence from previously analyzed LEED-CI sub-scheme can add information regarding practioners' preferences in LEED category performance; further, evidence can help recognize the sub-schemes that are performed with a high number of points and those that are performed with a low number of points. This recognition may help LEED experts correct low-performed categories in further versions of the LEED-CI sub-scheme toward a proper balance among the performances of the LEED categories. In addition, the findings of this study may help researchers dealing with LEED empirical studies to use better statistical methods, thereby obtaining more appropriate conclusions for green building development.

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