Article

LEED-CIv4 Commercial Interiors: United States (2014–2019)

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Abstract: This paper analyzes Leadership in Energy and Environmental Design for Interior Design and Construction: Commercial Interior (LEED-CIv4) projects, thereby presenting the first empirical evidence of these projects. The aim of the study was to reveal trends in Certified, Silver, Gold, and Platinum LEED-CIv4 US projects, certified in 2014–2019. The effect size between possible and achieved points in categories and credits was measured using Cliff’s δ. The following conclusions were drawn: (i) the Integrative Process, Innovation, and Regional Priority categories showed high achievements only in Platinum projects, so it is necessary to reconsider these categories toward increasing their acceptance at all certification levels; (ii) the Location and Transportation and Indoor Environmental Quality categories were quite well-designed because most credits in these categories showed varying levels of achievement (low/medium/high/very high) at all four certification levels; and (iii) the Water Efficiency, Energy and Atmosphere, and Material and Resources categories were badly designed because most credits there similarly showed low achievements at all four certification levels, thus needing more attention toward their improvement in the next LEED-CI version.

Keywords: LEED-CIv4; effect size; credit/category achievement

1. Introduction

It is well known that the construction sector is the largest consumer of energy and raw materials and is a producer of solid waste and emissions. In particular, it consumes 40% of global energy and produces 40% and 30% of the world’s solid waste and greenhouse emissions, respectively [1]. A global approach for dealing with such harm-building influence is building certifications under green systems, such as the Comprehensive Assessment System for Built Environment Efficiency (CASBEE) [2], the BRE Environmental Assessment Method (BREEAM) [3], the Sustainable Building Tool (SBTool) [4], Green Star [5], and Leadership in Energy and Environmental Design (LEED) [6].

In this respect, LEED is a well-known mature rating system. It was launched in 1998 by the United States Green Building Council (USGBC) [7]. For different types of buildings, USGBC suggested a relevant LEED system, such as LEED-NC for new construction buildings, LEED-EB for existing buildings, LEED-C and S for core and shell development, and LEED-CI for commercial interiors. Currently, LEED is widely applied in the United States and elsewhere globally. Around the world, 5340 LEED-NCv2.2 certified projects [8] and 3416 LEED-NCv3 certified projects [9] have been analyzed. In the US, 920 [10] and 1598 [11] LEED-NCv3 Silver and Gold projects, respectively, have been studied. In Turkey, Spain, and Italy, 108 LEED-CIv3 and LEED-C and S Gold projects [12] and in Finland, Sweden, Turkey, and Spain, 133 LEED-NCv3 projects [13] were evaluated. Thus, LEED-NC is the most popular system and often issued by design teams [14].

As a consequence, most empirical studies deal with LEED-NC, and well-grounded certification results of LEED-NC projects can be found in the literature. According to these findings, global Certified, Silver, Gold, and Platinum LEED-NCv3 projects (including those of the US) showed medium achievements in the Sustainable Sites (SS), Water Efficiency (WE), Indoor Environmental Quality...
(EQ), and Innovation (IN) categories (59.1–69.8% of possible points), and low achievements in Energy and Atmosphere (EA) and Materials and Resources (MR) (40.3 and 38.7% of possible points; [9]). In 10 states in the US (California, Florida, Georgia, Illinois, Massachusetts, New York, Ohio, Texas, Virginia, and Washington), Silver and Gold LEED-NCv3 projects certified in 2016 demonstrated medium achievements in the SS, WE, EQ, and IN categories (56.0–68.3% of possible points), and low achievements in EA and MR (30% and 41% of possible points, respectively) [10]. However, these NC-relevant findings cannot be applied to other LEED systems due to unavoidable differences between these schemes. In particular, NC-relevant findings seem to be unsuitable for CI projects. This is because the CI system covers mostly interior design, while the NC system covers both interior and exterior designs [15]. For example, SS has less influence on LEED-CIv3 (21 possible points) than on LEED-NCv3 (26 possible points), while EA has more weight in LEED-CIv3 (37 possible points) than in LEED-NCv3 (35 possible points) [16,17].

However, a very limited number of empirical LEED-CI studies can be found in the literature [15,18]. Fuerst [18] studied LEED-CI projects with LEED-NC, LEED-EB, and LEED-C and S, evaluating over 2000 projects in total that were registered in the US as of March 2009. Thus, version 2 of these systems was evaluated. LEED-CIv2 [19] consists of the following categories: SS (seven possible points), WE (two possible points), EA (12 possible points), MR (14 possible points), EQ (17 possible points), and IN (five possible points). To be Certified, Silver, Gold, or Platinum, projects need to achieve a total of 21–26, 27–31, 32–41, and 42–57 points, respectively. Thus, Fuerst [20] concluded that certification (a sum of possible points under the SS, WE, EA, MR, EQ, and IN categories) of the certified projects under the four systems (including CI system) was low and clustered at nearly the lower boundary of each certification level.

However, different weighting was applied to the next LEED-CIv3 [16]. Possible points became 21, 11, 37, 14, 17, and 6 for the SS, WE, EA, MR, EQ, and IN categories, respectively. Moreover, a Regional Priority (RP) category (four possible points) was introduced in LEED-CIv3 [16]. RP is a “bonus-points” category that is aimed to enforce US regional environmental issues. This means that if US regional environmental issues present achieved credits of SS, WE, EA, MR, and EQ categories, bonus RP points can be awarded. As a result, LEED-CIv3 [16] has 110 points in total. To obtain Certified, Silver, Gold, and Platinum, projects need to achieve a total of 40–49, 50–59, 60–79, and 80 points and above, respectively [16].

Pushkar and Verbitsky [15] analyzed Silver and Gold LEED-CIv3 projects in 14 US states and reported that certification achievement of Silver- and Gold-certified projects was low (51–57 and 62–71 achieved points, respectively). In addition, Pushkar and Verbitsky [15] reported that in both Silver- and Gold-certified projects, SS, WE, and ID showed high achievements, EA and EQ showed medium achievements, and MR showed low achievements.

However, the current LEED-CIv4 [20] differs from the previous LEED-CIv3 [16]. In particular, the SS category (26 possible points in LEED-CIv3) was replaced with Location and Transportation (LT, 18 possible points) in LEED-CIv4. In addition, there are requirement differences in some credits between versions 3 and 4 of the CI system. For example, in LEED-CIv3 [16], Optimize Energy Performance (EA category) was covered by four separate sub-credits: Eac1.1 (Lighting Power), Eac1.2 (Lighting Control), Eac1.3 (Heating, Ventilating, and Air Conditioning) (HVAC), and Eac1.4 (Equipment and Appliances). However, in LEED-CIv4 [20], this issue was presented by a single credit, EAc1 (Optimize Energy Performance), which covers lighting, HVAC, equipment, and appliances. Moreover, compared with LEED-CIv3 [16], most MR requirements were cardinally reformulated in LEED-CIv4 [20]. This introduced for the first time the life-cycle assessment (LCA) of building products and materials. Thus, even though the current LEED-CIv4 [20] also has 110 points in total, empirical evidence of LEED-CIv4 projects can be different from that of LEED-CIv3 projects, like the previous LEED-CIv3 [16].
However, empirical evidence of LEED-CIv4 projects has not yet been reported. Thus, the aim of this study was to analyze Certified, Silver, Gold, and Platinum LEED-CIv4 projects in the US during 2014–2019 toward revealing successful and unsuccessful credits in category achievement. This analysis would provide the first empirical evidence from commercial interior projects and may help LEED experts to correct future versions of LEED-CI toward a better category balance.

2. Materials and Methods

2.1. Data Collection

This study evaluates projects that were rated as Certified, Silver, Gold, and Platinum via the LEED-CIv4 [20] certification system. In total, 144 such projects certified from August 2014 to October 2019 were found in the USGBC project directory [21]. In particular, 63, 40, 36, and 4 projects received Certified, Silver, Gold, and Platinum certification, respectively (Table 1). Table 2 demonstrates that the Certified, Silver, and Gold projects were located across 10 US Environmental Protection Agency [EPA] climate regions, whereas Platinum projects were located only in 1, 3, 5, and 9 regions. Thus, all scorecards of these projects were downloaded from the USGBC project directory [21]. The achieved points in the IP, LT, WE, EA, MR, EQ, IN, and RP categories were accumulated in an Excel database.

Table 1. Distribution of LEED-CIv4 Certified, Silver, Gold, and Platinum projects in US states in 2014–2019.

| Certification | DC (11), CA (10), NY (7), MA (3), MO (3), NC (3), NJ (3), PA (3), FL (2), IL (2), NV (2), OR (2), TX (2), VA (2), CO (1), GA (1), MD (1), MI (1), MN (1), TN (1), VT (1), WA (1). |
| Certified | CA (14), IL (5), NY (4), TN (3), FL (2), MA (2), TX (2), CO (1), DC (1), MD (1), MI (1), NC (1), NM (1), OH (1), PA (1). |
| Gold | CA (11), MA (4), NY (4), IL (3), WA (3), CO (2), NJ (2), TX (2), VA (2), FL (1), MD (1), NC (1). |
| Platinum | CA (1), IL (1), MA (1), VA (1). |

CA: California; CO: Colorado; DC: District of Columbia; FL: Florida; GA: Georgia; IL: Illinois; MA: Massachusetts; MD: Maryland; MI: Michigan; MN: Minnesota; MO: Missouri; NC: North Carolina; NJ: New Jersey; NM: New Mexico; NV: Nevada; NY: New York; OH: Ohio; OR: Oregon; PA: Pennsylvania; TN: Tennessee; TX: Texas; VA: Virginia; VT: Vermont; WA: Washington.

Table 2. Distribution of LEED-CIv4 Certified, Silver, Gold, and Platinum projects (2014–2019) in US climate regions.

| Certification | MA, VT [1]; NY, NJ, [2]; DC, PA VA, MD [3]; GA, NC, FL, TN, [4]; IL, MI, MN [5]; TX [6]; MO [7]; CO [8]; CA [9]; OR, WA [10]. |
| Certified | MA [1]; NY [2]; DC, MD, PA [3]; FL, NC, TN [4]; IL, MI, OH [5]; TX, NM [6]; CO [8]; CA [9]. |
| Gold | MA [1]; NY, NJ [2]; VA, MD [3]; FL, NC [4]; IL [5]; TX [6]; CO [8]; CA [9]; WA [10]. |
| Platinum | MA [1]; VA [3]; IL [5]; CA [9]. |

Climate regions are according to the US Environmental Protection Agency (EPA) regional classification system [22].

2.2. Statistical Analysis

For descriptive statistics, we used the median–interquartile range (IQR; 25th–75th percentile) instead of the mean ± standard deviation because LEED data are associated with an ordinal scale. For inferential statistics, we used the nonparametric Cliff’s $\delta$ effect size test instead of the parametric Cohen’s d-test because the assumption of normality for LEED data was not met. Cliff’s $\delta$ measures the difference magnitude between two distributions [23]. In the present study, effect size was measured between possible and achieved points in a category and credits for each certification level of LEED-CIv4.
projects. Three items should be noted: to perform nonparametric tests for independent groups, the minimum sample size was \( n_1 = n_2 = 4 \) [24] (p. 19). In the present study, the minimum sample size was \( n_1 = n_2 = 4 \). (ii) Bergmann et al. [25] used the Wilcoxon–Mann–Whitney (WMW) nonparametric test when one of the two groups contained the same values (“somewhat unusual dataset”). In parallel, Cliff [23] noted that the WMW U statistic can be used to estimate nonparametric effect size. (iii) We focused on substantive significance (effect size), but not statistical significance (P value) in the analysis of LEED-Clv4 projects because statistical significance depends on sample size, while effect size does not [15].

Cliff’s \( \delta \) ranged between –1 and +1; positive (+) values meant that Group 1 was larger than Group 2, null (0) meant equality or overlap, and negative (–) values meant that Group 2 was larger than Group 1 [23]. According to Romano et al. [26], effect size was considered to be (i) negligible if \( |\delta| < 0.147 \), (ii) small if \( 0.147 < |\delta| < 0.33 \), (iii) medium if \( 0.33 < |\delta| < 0.474 \), and (iv) large if \( |\delta| \geq 0.474 \). In this study, in order to evaluate Cliff’s \( \delta \) effect sizes between possible and achieved points, we reformulated the effect size as the following: (i) very high achieved points if \( |\delta| < 0.147 \), (ii) high achieved points if \( 0.147 < |\delta| < 0.33 \), (iii) medium achieved points if \( 0.33 < |\delta| < 0.474 \), and (iv) low achieved points if \( |\delta| \geq 0.474 \).

According to Cohen [27] (p. 156), a medium-achieved-point effect is “visible to the naked eye of a careful observer.” A low-achieved-point effect is “noticeably smaller than medium but not so small as to be trivial.” A high-achieved point’s effect is “the same distance above the medium as small is below it.” It should be remembered that effect size is not “iron-clad criteria” [28], but only a general rule of thumb that might be followed in the absence of knowledge of the area [29].

3. Results and Discussion

3.1. LEED-Clv4 Categories

As observed in Table 3, Cliff’s \( \delta \) effect sizes between possible and achieved points in eight categories at all certification levels were mostly similar. In particular, only in three categories (IP, IN, and RP) did Platinum projects show high achievement, whereas Certified, Silver, and Gold projects demonstrated low achievement. The IP category contained only one credit that required preliminary analysis of the inter-relationships between energy- and water-related systems [22]. It can be suggested that such early analysis was necessary for Platinum projects, which were aimed to emphasize EA with 31.5 ± 7.5 from 38 possible points achieved (Table 3). The IN category has two credits: Innovation credit (five possible points) and LEED-accredited professional credit (one possible point, [20]). As was noted during IN data accumulation, almost all projects at the four certification levels hired an LEED-accredited professional. Thus, the Innovation issue (credit) was taken into account only at the Platinum level of certification. RP allows for receiving up to four possible bonus points by performing regional-related credits in the LT, WE, EA, MR, and EQ categories [20]. These regional issues were emphasized only at the highest level (Platinum).

We also included only one credit, that is, Indoor-water-use reduction (12 possible points). This credit had low achievement at the four certification levels, decreasing potable water use by approximately 35% (six achieved points, Table 3) from the calculated baseline in the Indoor-water-use-reduction prerequisite, whereas 50% of potable water saving was required to receive 12 possible points.

The performance of the LT, EA, MR, and EQ categories was also low at the four certification levels (Table 3). These categories included a number of credits, so detailed category-related analysis was conducted. Results are presented in Tables 4–7 below.
Table 3. Categories of LEED-CiV4 projects: median ± interquartile range (IQR; 25th–75th percentile) and Cliff’s δ effect size between possible and achieved points in a category.

| Category                        | Possible Points | Achieved Points | Certified | Silver | Gold | Platinum |
|---------------------------------|-----------------|-----------------|----------|--------|------|----------|
| Integrative Process             | 2               |                 | 0.0 ± 2.0 | 0.0 ± 2.0 | 1.0 ± 2.0 | 2.0 ± 0.5 |
| Location and Transportation     | 18              |                 | 14.0 ± 10.5 | 14.5 ± 8.5 | 17.0 ± 6.0 | 17.0 ± 3.5 |
| Water Efficiency                | 12              |                 | 6.0 ± 2.0 | 6.0 ± 2.0 | 6.0 ± 2.0 | 6.0 ± 4.0 |
| Energy and Atmosphere           | 38              |                 | 12.0 ± 4.0 | 14.0 ± 7.5 | 22.5 ± 13.0 | 31.5 ± 7.5 |
| Material and Resources          | 13              |                 | 4.0 ± 1.0 | 5.0 ± 2.0 | 5.0 ± 2.5 | 6.0 ± 1.0 |
| Indoor Environmental Quality    | 17              |                 | 5.0 ± 3.0 | 5.0 ± 2.5 | 6.5 ± 4.0 | 9.0 ± 1.0 |
| Innovation                      | 6               |                 | 4.0 ± 2.0 | 5.0 ± 2.0 | 5.0 ± 2.0 | 6.0 ± 0.5 |
| Regional Priority               | 4               |                 | 2.0 ± 1.8 | 3.0 ± 1.0 | 3.0 ± 1.0 | 4.0 ± 0.5 |

Table 4. Credit points achieved for the Location and Transportation category of LEED-CiV4 projects: median ± interquartile range (IQR; 25th–75th percentile) and Cliff’s δ effect size of differences between possible and achieved points in a credit.

| Credit                          | Possible Points | Achieved Points | Certified | Silver | Gold | Platinum |
|---------------------------------|-----------------|-----------------|----------|--------|------|----------|
| Surrounding Density and Diverse Uses | 8              |                 | 8.0 ± 6.0 | 8.0 ± 3.0 | 8.0 ± 3.0 | 8.0 ± 1.5 |
| Access to Quality Transit       | 7               |                 | 7.0 ± 7.0 | 6.0 ± 7.0 | 7.0 ± 1.0 | 7.0 ± 2.0 |
| Bicycle Facilities              | 1               |                 | 0.0 ± 0.0 | 0.0 ± 1.0 | 0.0 ± 1.0 | 0.5 ± 1.0 |
| Reduced Parking Footprint       | 2               |                 | 0.0 ± 1.0 | 0.0 ± 2.0 | 2.0 ± 2.0 | 2.0 ± 0.0 |

Table 5. Credit points achieved for the Energy and Atmosphere category of LEED-CiV4 projects: median ± interquartile range (IQR; 25th–75th percentile) and Cliff’s δ effect size between possible and achieved points in a credit.

| Credit                          | Possible Points | Achieved Points | Certified | Silver | Gold | Platinum |
|---------------------------------|-----------------|-----------------|----------|--------|------|----------|
| Enhanced Commissioning          | 5               |                 | 4.0 ± 3.8 | 4.0 ± 0.0 | 4.0 ± 1.0 | 4.5 ± 1.0 |
| Advanced Energy Metering        | 2               |                 | 0.0 ± 1.0 | 0.0 ± 1.0 | 1.0 ± 1.5 | 2.0 ± 0.0 |
| Renewable Energy Production     | 3               |                 | 0.0 ± 0.0 | 0.0 ± 1.0 | 0.0 ± 1.0 | 0.0 ± 1.5 |
| Enhanced Refrigerant Management | 1               |                 | 0.0 ± 0.8 | 0.0 ± 1.0 | 0.0 ± 1.0 | 0.5 ± 1.0 |
| Green Power and Carbon Offsets  | 2               |                 | 1.0 ± 2.0 | 2.0 ± 2.0 | 2.0 ± 0.5 | 2.0 ± 0.0 |
| Optimize Energy Performance     | 25              |                 | 7.0 ± 2.0 | 8.5 ± 8.0 | 15.0 ± 11.5 | 23.0 ± 7.0 |
Table 6. Credit points achieved for the Material and Resources category of LEED-CIv4 projects: median ± interquartile range (IQR; 25th–75th percentile) and Cliff’s δ effect size between possible and achieved points in a credit.

| Credit                                | Possible Points | Achieved Points       |
|----------------------------------------|-----------------|-----------------------|
|                                        | Certified       | Silver | Gold | Platinum |
| Long-Term Commitment                   | 1               | 1.0 ± 1.0             | 1.0 ± 0.0 | 1.0 ± 0.0 | 1.0 ± 0.0 |
|                                        | 0.27            | 0.15  | 0.19  | 0.00      |
| Interiors Life-Cycle Impact Reduction  | 4               | 0.0 ± 0.0             | 0.0 ± 1.0 | 1.0 ± 1.0 | 1.0 ± 0.5  |
|                                        | 1.00            | 1.00  | 1.00  | 1.00      |
| BPD and O—Environmental Product Declar| 2               | 1.0 ± 1.0             | 1.0 ± 1.0 | 1.0 ± 1.0 | 1.0 ± 0.5  |
|                                        | 1.00            | 1.00  | 1.00  | 1.00      |
| BPD and O—Sourcing of Raw Materials    | 2               | 0.0 ± 1.0             | 0.0 ± 1.0 | 0.0 ± 1.0 | 0.5 ± 1.0  |
|                                        | 1.00            | 0.97  | 0.97  | 1.00      |
| BPD and O—Material Ingredients         | 2               | 0.0 ± 1.0             | 1.0 ± 1.0 | 1.0 ± 1.0 | 1.0 ± 0.0  |
|                                        | 0.95            | 0.93  | 1.00  | 1.00      |
| Construction and Demolition Waste Man| 2               | 2.0 ± 1.0             | 2.0 ± 1.0 | 2.0 ± 1.0 | 2.0 ± 0.0  |
|                                        | 0.40            | 0.33  | 0.28  | 0.00      |

Table 7. Credit points achieved for the Indoor Environmental Quality category of LEED-EBv4 projects: median ± interquartile range (IQR; 25th–75th percentile) and Cliff’s δ effect size between possible and achieved points in a credit.

| Credit                                | Possible Points | Achieved Points       |
|----------------------------------------|-----------------|-----------------------|
|                                        | Certified       | Silver | Gold | Platinum |
| Enhanced Indoor Air Quality Strategies | 2               | 1.0 ± 2.0             | 1.5 ± 1.0 | 1.5 ± 1.0 | 1.5 ± 1.5  |
|                                        | 0.65            | 0.47  | 0.50  | 0.50      |
| Low-Emitting Materials                 | 3               | 1.0 ± 2.8             | 1.0 ± 2.0 | 1.0 ± 3.0 | 2.0 ± 1.0  |
|                                        | 0.75            | 0.70  | 0.72  | 0.75      |
| Construction Indoor Air Quality        | 1               | 1.0 ± 0.0             | 1.0 ± 0.0 | 1.0 ± 0.0 | 1.0 ± 0.0  |
| Management Plan                        | 0.06            | 0.00  | 0.08  | 0.00      |
| Indoor Air Quality Assessment          | 2               | 0.0 ± 1.0             | 0.0 ± 0.5 | 0.0 ± 2.0 | 2.0 ± 0.5  |
|                                        | 0.86            | 0.90  | 0.58  | 0.25      |
| Thermal Comfort                        | 1               | 0.0 ± 0.0             | 0.0 ± 0.0 | 0.0 ± 0.0 | 0.5 ± 1.0  |
|                                        | 0.87            | 0.88  | 0.78  | 0.50      |
| Interior Lighting                      | 2               | 0.0 ± 1.0             | 0.5 ± 1.0 | 1.0 ± 1.0 | 2.0 ± 0.5  |
|                                        | 0.94            | 0.90  | 0.78  | 0.25      |
| Daylight                               | 3               | 0.0 ± 0.0             | 0.0 ± 0.0 | 0.0 ± 0.0 | 0.0 ± 0.5  |
|                                        | 0.97            | 0.95  | 0.94  | 1.00      |
| Quality Views                          | 1               | 0.0 ± 1.0             | 0.0 ± 1.0 | 1.0 ± 1.0 | 1.0 ± 0.0  |
|                                        | 0.71            | 0.60  | 0.44  | 0.00      |
| Acoustic Performance                   | 2               | 0.0 ± 0.0             | 0.0 ± 0.0 | 0.0 ± 0.0 | 0.0 ± 0.0  |
|                                        | 0.97            | 0.95  | 0.94  | 1.00      |

3.2. Location and Transportation

As can be noted from Table 4, at the four certification levels, only one of the four LT credits had similar Cliff’s δ effect sizes between possible and achieved points. The Bicycle Facilities credit showed low achievement in Certified, Silver, Gold, and Platinum projects. It should be noted that this credit does not impose great changes on supplemental bicycle infrastructure, requiring only project-related
bicycle storage for building occupants and visitors near the project entrance (30 meters’ walking distance) and showers with changing facilities [20].

Three of the four LT credits had different Cliff’s δ effect sizes between possible and achieved points at the four certification levels. The Surrounding Density and Diverse Uses credit demonstrated medium achievement in Certified and Silver projects, and high in Gold and Platinum projects. This credit was not in the design team’s authority because it depends on the walking distance between an existing building (in which CI reconstruction or renovation takes place) and different public services such as banks, education facilities, and restaurants [20]. It seems that these public services were more available for Gold and Platinum projects.

Access to Quality Transit showed low achievement in Silver projects, medium achievement in Certified and Gold projects, and high achievement in Platinum projects. It seems that this credit was again not under the design team’s authority because it depends on walking distance between an existing building (in which CI reconstruction or renovation takes place) and different public-transportation stations such as bus stops, rail stations, and ferry terminals [20].

Reduced Parking Footprint showed low achievement in Certified and Silver projects, medium in Gold projects, and very high in Platinum projects. This credit was more under design-team authority because it requires preferability to carpool parking, thereby decreasing private parking spaces [20].

3.3. Energy and Atmosphere

As noted from Table 5, at the four certification levels, four of the six EA credits had similar Cliff’s δ effect sizes between possible and achieved points. Enhanced Commissioning, Renewable Energy Production, Enhanced Refrigerant Management, and Optimize Energy Performance credits showed similar low achievement at all four certification levels. Enhanced Commissioning requires commissioned surveys of mechanical, electrical, domestic hot water, and renewable energy systems [20]. Renewable Energy Production aims to decrease environmental damage from fossil-fuel-based energy by the direct installation of renewable-energy systems or the purchase of renewable power from other sources. Enhanced Refrigerant Management encourages decreases in global warming potential (GWP) and ozone depletion potential (ODP) by prohibiting refrigerants, or by using refrigerants with low ODP and GWP [20]. Optimize Energy Performance requires decreasing operational energy through insulating building envelopes and installing efficient HVAC systems, interior lighting power and controls, and equipment and appliances [20]. Despite the importance of energy saving issues presented in these credits from different approaches, these requirements still had less demand.

The Advanced Energy Metering and Green Power and Carbon Offsets credits had different Cliff’s δ effect sizes between possible and achieved points at the different certification levels (Table 5). Advanced Energy Metering showed low achievement at the Certified, Silver, and Gold levels, and very high at the Platinum levels. This credit encourages the installation of advanced energy metering systems for all sources of tenant energy used in a project [20], and only at the highest certification level was this credit achieved by the project teams. Green Power and Carbon Offsets gradually increased from low in Certified projects, to medium in Silver projects, high in Gold projects, and very high in Platinum projects. This credit is related to engaging in a contract for qualified resources of green power, carbon offsets, or renewable energy certificates, and it also had less demand.

3.4. Materials and Resources

As can be noted from Table 6, at the four certification levels, four of the six MR credits had similar Cliff’s δ effect sizes between possible and achieved points. Interiors Life-Cycle Impact Reduction requires interior reuse, furniture reuse, and/or flexible interior design [20], and it was lowly achieved at all four certification levels. The Building Product Disclosure and Optimization (BPD and O)—Environmental Product Declarations, the BPD and O—Sourcing of Raw Materials, and the BPD and O—Material Ingredients credits demonstrated low achievement at each level of certification. These three credits require the use of products and materials with available LCA declaration [20], and such LCA-evaluated
products and materials can be costly because they involve LCA-related consultants, software tools, and datasets.

Long-Term Commitment and Construction and Demolition Waste Management credits had different Cliff’s $\delta$ effect sizes between possible and achieved points at different certification levels (Table 6). Long-Term Commitment showed high achievement at the Certified, Silver, and Gold levels, and very high achievement at the Platinum level. This credit aims to decrease environmental damage from materials production and transport for tenant relocation, requiring tenants’ commitment to stay in the same building for at least 10 years [20]. Construction and Demolition Waste Management gradually increased from medium in Certified and Silver projects, to high in Gold projects, and very high in Platinum projects. This credit requires recycling and/or salvaging nonhazardous construction and demolition materials and was met by design teams at all four certification levels.

### 3.5. Indoor Environmental Quality

At the four certification levels, five of the nine EQ credits had similar Cliff’s $\delta$ effect sizes between possible and achieved points, as seen in Table 7. Among these credits, only the Construction Indoor Air Quality Management credit, which aims at improving indoor air quality during building construction and renovation, had very high achievement, whereas the Low-Emitting Materials, Thermal Comfort, Daylight, and Acoustic Performance credits had low achievement at each level of certification. Low-Emitting Materials aims at using low volatile organic compound (VOC) interior materials and products such as paints, adhesives, sealants, composite wood, and furniture [20] that might increase the project budget. This credit was lowly achieved at all four certification levels. Thermal Comfort, Daylight, and Acoustic Performance also showed low achievement at all four certification levels. Thermal Comfort relates to the installation of control systems for the regulation of air temperature, humidity, and speed in occupied spaces, Acoustic Performance requires sound isolation to restrict background noise levels from HVAC systems, and Daylight requires that maximum daylight is provided and glare-control devices are installed in occupied spaces, therefore relating to window design [20]. Such purchases of control systems and performances of sound isolation might increase the project budget, whereas window design can be restricted by other design demands, such as decreased operational energy for heating and cooling needs.

The Enhanced Indoor Air Quality Strategies, Indoor Air Quality Assessment, Interior Lighting, and Quality Views credits had different Cliff’s $\delta$ effect sizes between possible and achieved points at different certification levels (Table 7). Enhanced Indoor Air Quality Strategies had small success, with medium achievement at the Platinum level, and low achievement at the Certified, Silver, and Gold levels. This credit aims to improve air quality by air filtration to decrease exterior contamination in mechanically ventilated spaces and to provide needed airflow for effective natural ventilation [20]. Indoor Air Quality Assessment, Interior Lighting, and Quality Views had more success, with very high or high achievement at the Platinum level, medium or low achievement at the Gold level, and low at the Silver and Certified levels. Indoor Air Quality Assessment aims to provide better quality of indoor air after construction and during occupancy and it requires a building air flush-out before occupancy and testing VOCs. Interior Lighting mostly requires the installation of lighting controls, and Quality Views requires the installation of vision glazing for most regularly occupied spaces and, therefore, in window design [20]. The Construction Indoor Air Quality Management Plan had the highest success, with very high achievement at all four certification levels.

### 4. Conclusions

This study performed an analysis of Certified, Silver, Gold, and Platinum LEED-CIv4 projects that were certified from August 2014 to October 2019 in the US. In conclusion, only two of the eight categories, LT and EQ, can be considered as well-designed. In these categories, almost all of the credits of these categories showed different levels of achievement among the four certification levels: better at high levels (Platinum and Gold) when compared to low levels (Silver and Certified).
IP showed high achievement only in Platinum projects, whereas both WE and EA categories demonstrated low achievement at all four certification levels. These categories can be viewed as two interrelated pairs, IP–WE and IP–EA, because the IP category deals with preliminary analyses of energy- and water-related systems. Thus, to raise the popularity of these categories, a stricter connection between the IP and WE categories and between the IP and EA categories through the Optimize Energy Performance credit is desired. This connection, for example, can be achieved by introducing IP as a prerequisite for both the WE and EA categories. In this way, design teams could be obliged to achieve the IP category requirements and stimulated to obtain higher achievements in the WE and EA categories.

The MR category was also recognized as showing low achievements at all four certification levels. A low popularity of the MR category was well-known from previous empirical studies of LEED-CIV3 [15]. Thus, despite the introduction of the LCA issue in LEED-CIV4, the attractiveness of this category is still low. Also in this case, it can be suggested that a prerequisite should be introduced to four LCA-related credits. This could help to involve design teams into the LCA issue more broadly.

The IN and RP categories in three of the four certifications, Certified, Silver, and Gold, showed low achievement, and only at the Platinum level was achievement high. Thus, it can be suggested that the weighting of these categories be increased so as to increase their attractiveness at all certification levels.

It should be noted that the aforementioned conclusions were drawn based only on LEED-CIV4 projects certified in the US. However, LEED is also the most recognized system in Europe and, as follows from the literature [13], European countries have addressed its applications in a different way compared to the US. In particular, in Northern European countries (Finland and Sweden), the Optimize Energy Performance credit (the EA category) of LEED-NCV3 projects showed high achievement [13]. Thus, in future research, a similar methodology needs to be applied to LEED-CI buildings in Europe so that the conclusions presented here can be more internationally accepted.

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Abbreviations

| Abbreviation | Full Form | Description |
|--------------|-----------|-------------|
| BPD and O    | Building Product Disclosure and Optimization | |
| EA           | Energy and Atmosphere | |
| EQ           | Indoor Environmental Quality | |
| GWP          | global warming potential | |
| HVAC         | heating, ventilating, and air conditioning | |
| IN           | Innovation | |
| LCA          | life-cycle assessment | |
| LEED-CIV4    | Leadership in Energy and Environmental Design: Commercial Interior | |
| LT           | Location and Transportation | |
| MR           | Materials and Resources | |
| ODP          | ozone depletion potential | |
| RP           | Regional Priority | |
| SS           | Sustainable Sites | |
| USGBC        | United States Green Building Council | |
| VOC          | volatile organic compound | |
| WE           | Water Efficiency | |
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