EPiC Series in Built Environment

Volume 7, 2026, Pages 475–484

Proceedings of Associated Schools of Construction 62nd Annual International Conference

Strategic Alignment in Green Building Certification: An Importance-Performance Analysis of LEED v4 New Construction Projects

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This study evaluates the relationship between credit-category importance and achieved performance in LEED v4 New Construction (NC) certified projects using a comprehensive Importance–Performance Analysis (IPA). A dataset of 1,344 certified projects was analyzed to assess how major LEED credit categories align with their relative weighting and market-level achievement. The results reveal that Location & Transportation (LT), Energy & Atmosphere (EA), and Indoor Environmental Quality (EQ) are positioned in the "Concentrate Here" quadrant, indicating high importance but below-average performance. Sustainable Sites (SS), Water Efficiency (WE), and Materials & Resources (MR) were classified as low importance and low performance, while Innovation (IN) and Regional Priority (RP) achieved above-average performance despite lower importance. A robustness test comparing mean- and median-based thresholds indicated moderate stability in the quadrant assignments, with EA, WE, and MR changing quadrant under the median-based specification. These findings identify key opportunities to improve strategic performance in the most influential LEED categories. The study contributes a robust, data-driven framework for assessing market-level certification dynamics and demonstrates the analytical reliability of IPA as a diagnostic tool for green-building evaluation. The results provide actionable insights for optimizing resource allocation and advancing performance-driven sustainability practices in the construction industry.

Keywords: LEED, New Construction, IPA, Green Building

Introduction

Sustainable construction has become a central priority in contemporary building practice due to the construction sector's substantial share of global resource consumption, energy demand, and carbon emissions. In response, certification systems such as the Leadership in Energy and Environmental Design (LEED) framework, developed by the U.S. Green Building Council, have been widely adopted to guide the design and delivery of environmentally responsible buildings. Within LEED v4 New Construction (NC), credits are organized into major categories, Location & Transportation (LT), Sustainable Sites (SS), Water Efficiency (WE), Energy & Atmosphere (EA), Materials & Resources (MR), Indoor Environmental Quality (EQ), Innovation (IN), Regional Priority (RP), and Integrative Process that collectively define the sustainable construction performance of a project. While LEED certification has become an established benchmark for green building, evidence suggests that project

teams may not always align their credit-achievement strategies with the categories that carry the greatest environmental or strategic significance. This potential disconnect between credit importance and credit performance raises important questions about the strategic efficiency of the certification process.

Over the past decade, research has increasingly examined how LEED credit categories contribute to overall certification outcomes and how project strategies reflect or deviate from the system's weighting structure. Early data-driven work by Ma and Cheng (2016) identified recurring patterns of "easy" versus "difficult" credits, revealing that project teams tend to prioritize more achievable credits rather than those with greater sustainability impact. Although insightful, their study did not directly relate credit performance to its assigned importance, leaving unexplored whether LEED's weighting system aligns with observed achievement trends.

Subsequent studies have deepened the analysis of credit influence and interdependence. Goodarzi et al. (2023) investigated the consistency of LEED credit weighting and found notable disparities between the theoretical weight of categories and their realized influence in certified projects, emphasizing the need to assess how weighting translates into practice. Expanding this perspective, Goodarzi et al. (2025) employed a network-analysis approach to map relationships among LEED-NC v3 credits, demonstrating that certain high-impact categories, such as EA, occupy central roles in certification dynamics even when underachieved in practice. Collectively, these findings suggest that credit-achievement patterns often diverge from the intended weighting logic of the LEED system (Goodarzi & Shayesteh, 2024).

Beyond credit achievement, several studies have examined the broader performance gap between certified and operational outcomes (e.g., Ahmad et al., 2025; Marzouk, 2024; Pushkar, 2022). Pushkar (2023) analyzed the "Optimize Energy Performance" credit and confirmed that the EA category remains the most influential but also the most variable in post-occupancy energy results. This highlights that shifts in rating-system weighting or structure can influence relative importance among categories, but it leaves unanswered how performance across categories aligns with those importances at scale. Likewise, Afroz et al. (2020) observed that LEED-certified buildings often fail to achieve the anticipated operational savings, attributing part of the discrepancy to misaligned design priorities. While this work addresses operational outcomes, it does not integrate the importance dimension and performance in the same analysis.

Despite these advancements, the literature reveals several persistent gaps. First, few studies systematically assess the relationship between credit importance and performance across all major LEED categories using a unified analytical framework. Second, Importance-Performance Analysis, widely applied in service and management research, has rarely been used to evaluate sustainability rating systems. Third, the robustness of classification outcomes under alternative statistical thresholds (mean vs. median) remains largely unexplored in green-building evaluation.

Addressing these gaps, this study applies Importance-Performance Analysis (IPA) to a large dataset of 1,344 LEED v4 NC certified projects to evaluate the alignment between credit-category importance and achieved performance, while testing classification stability under different central-tendency assumptions. By doing so, it contributes new empirical evidence on the strategic efficiency of LEED implementation and provides a replicable methodological framework for prioritizing improvement efforts in sustainable construction practice.

Method

Data collection and preparation

Project-level credit data were obtained from the publicly accessible USGBC LEED Project Directory. Projects were filtered to include only those certified under LEED v4 New Construction and possessing complete category-level point information. Records with missing category totals or inconsistent point allocations were excluded. For each project, achieved and possible points were aggregated at the credit-category level to ensure consistency with the LEED v4 scorecard structure. All extracted values were cross-checked against category point maxima to confirm internal validity prior to normalization.

The dataset comprised 1,344 LEED v4 New Construction–certified projects across all certification levels (Certified, Silver, Gold, and Platinum). Certifications span the active period of LEED v4 implementation, capturing projects certified over multiple years rather than a single certification cycle. As a result, the dataset reflects aggregate market-level certification behavior under LEED v4 but may underrepresent regional or building-type contexts where LEED adoption is less prevalent.

To enable comparison across categories with differing point allocations, performance values were normalized to a 1–100 scale representing the average percentage of achieved points within each category. Likewise, importance values were normalized to represent the proportion of each category's possible points relative to the LEED v4 total (110 points). Mean values of normalized importance (12.39) and performance (53.52) were used as the central thresholds to define quadrant boundaries in the IPA. Normalized performance for each category $i$was calculated as:

$$\text{Performance}_i = \left(\frac{\text{Mean Points Achieved}_i}{\text{Possible Points}_i}\right) \times 100$$

Normalized importance for each category $i$was calculated as:

$$\text{Importance}_i = \left(\frac{\text{Possible Points}_i}{110}\right) \times 100$$

These transformations ensure that all categories are evaluated on a consistent scale reflecting their relative contribution to the overall LEED scorecard.

Rationale for aggregation and threshold selection

In this study, category importance is operationalized using the point allocation structure defined by LEED v4, reflecting the internal logic of the rating system in which point weights encode the relative priority assigned to different sustainability domains. Combining this system-internal importance measure with category-level averaging enables assessment of market-level achievement patterns aligned with LEED's strategic intent, rather than project-specific optimization strategies or externally imposed weighting schemes. This approach is consistent with prior portfolio-scale analyses of LEED credit influence (Ma & Cheng, 2016; Goodarzi et al., 2023). Mean values were selected as the primary IPA thresholds because they preserve proportional sensitivity to higher-impact categories and are commonly used in IPA applications; however, given documented skewness in LEED credit achievement, a median-based IPA was also conducted as a robustness check to assess classification stability under more conservative cutoffs.

Data Analysis

The IPA framework was applied to evaluate the relative performance and strategic priority of each LEED credit category. Categories were plotted on a two-dimensional grid where the x-axis represents normalized performance, and the y-axis represents normalized importance. The grand means of performance (53.52) and importance (12.39) served as cutoffs dividing the plane into four quadrants: (1) Quadrant I: Keep Up the Good Work: High importance, high performance; (2) Quadrant II: Concentrate Here: High importance, low performance; (3) Quadrant III: Possible Overkill: Low importance, high performance; and (4) Quadrant IV: Low Priority: Low importance, low performance Each category's position relative to the thresholds determined its quadrant assignment. Following the initial IPA, Quadrant Stability and Robustness Checks were conducted to test the sensitivity of quadrant classifications to alternative cutoff definitions, specifically median-based thresholds. The percentage of categories retaining their quadrant across the alternative method quantified overall classification stability.

Results

Overall IPA for all LEED-certified Projects

The IPA conducted on the full dataset of 1,344 projects provides an aggregate view of how the primary LEED credit categories perform relative to their strategic significance within the LEED v4 scorecard. Table 1 reports, for each category, the mean points achieved, the normalized performance score, the possible points, the normalized importance score, the binary performance and importance positions (relative to the grand means), and the resulting IPA quadrant classification.

Table 1. Overall IPA for all project types (N= 1344)

Category	M-Points	Perf.	Possible Points	Imp.	Perf.	Imp.	Quadrant
LT	7.21	45.03	16	14.55	0	1	II. Concentrate Here
SS	4.71	47.13	10	9.09	0	0	IV. Low Priority
WE	5.49	49.9	11	10.00	0	0	IV. Low Priority
EA	17.35	52.57	33	30.00	0	1	II. Concentrate Here
MR	5.41	41.58	13	11.82	0	0	IV. Low Priority
EQ	7.20	44.97	16	14.55	0	1	II. Concentrate Here
RP	2.65	66.33	4	3.64	1	0	III. Possible Overkill
IN	4.84	80.62	6	5.46	1	0	III. Possible Overkill
Mean		53.52		12.39			

Figure 1 visualizes these results on the two-dimensional IPA grid using the grand means of performance (53.52) and importance (12.39) as the horizontal and vertical cutoffs, respectively.

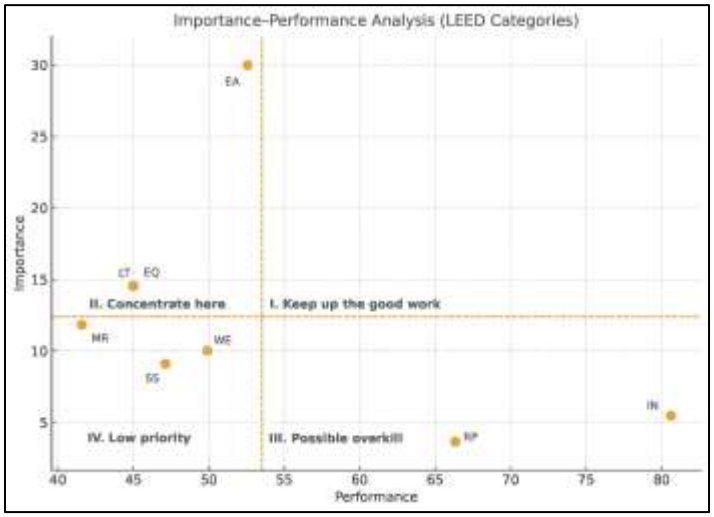

Figure 1. Importance Performance Analysis of all credit categories

In Figure 1, the clustering of LT, EA, and EQ in Quadrant II underscores the central empirical finding of the IPA: the most consequential LEED v4 categories, those that control large portions of the available 110 points, are not being fully leveraged across the 1,344 certified projects. This pattern signals a system-level opportunity for targeted performance enhancement in precisely those categories that matter most for certification outcomes. The placement of SS, WE, and MR in Quadrant IV corroborates their comparatively smaller role in the total LEED score and their below-mean achievement levels, making them secondary candidates for intervention in a context of limited resources. The position of IN and RP in Quadrant III further indicates that these discretionary or context-specific credits are being achieved at relatively high rates despite their lower contribution to the overall score, which may reflect ease of attainment or project teams' strategic choices to secure available points outside the core technical categories. The absence of any category in Quadrant I confirms that, for this dataset, high importance and high performance do not coincide at the aggregate level, which in turn justifies the subsequent robustness checks.

Quadrant Stability and Robustness Check

To assess whether the quadrant assignments were sensitive to the choice of central-tendency measure, the IPA was recomputed using median-based thresholds rather than the original mean-based thresholds. Consistent with the IPA procedure described in the Methods section, the category-level normalized performance and importance values reported in Table 1 were retained, and only the central crosshair values were changed. The original mean-based IPA used cutoffs of 53.52 for normalized performance and 12.39 for normalized importance, whereas the robustness check used median-based cutoffs of 47.68 and 10.91, respectively. Because both median thresholds are lower than their mean counterparts, the median-based IPA applies less restrictive cutoffs for classifying categories as high performance and high importance.

Table 2 compares the quadrant assignments under the two specifications. Using the median-based thresholds, 5 of the 8 categories retained their original quadrant, yielding an overall stability rate of 62.5%. Three categories changed quadrant assignment. EA shifted from Quadrant II to Quadrant I, because its performance value exceeded the lower median performance cutoff while remaining above

the importance threshold. MR moved from Quadrant IV to Quadrant II, because its importance value exceeded the lower median importance cutoff even though its performance remained below the median performance threshold. WE shifted from Quadrant IV to Quadrant III, because its performance exceeded the median performance cutoff while its importance remained below the median importance cutoff. These movements indicate that the robustness check does not overturn the main IPA pattern, but it does show that categories located near the original cutoffs are sensitive to the threshold definition.

Table 2. Comparison of mean-based and median-based quadrant assignments

Category	Performance	Importance	Quadrant (Mean-based)	Quadrant (Median-based)	Change
LT	45.03	14.55	II	II	No
SS	47.13	9.09	IV	IV	No
WE	49.90	10.00	IV	III	Yes
EA	52.57	30.00	II	I	Yes
MR	41.58	11.82	IV	II	Yes
EQ	44.97	14.55	II	II	No
RP	66.33	3.64	III	III	No
IN	80.62	5.46	III	III	No

Note: Category-level normalized performance and importance values are unchanged from Table 1. Median-based IPA uses only revised cutoffs: performance = 47.68 and importance = 10.91.

The overall distribution of categories across quadrants under the two specifications is summarized in Table 3. Under the mean-based IPA, the categories were distributed as follows: 0 in Quadrant I, 3 in Quadrant II, 2 in Quadrant III, and 3 in Quadrant IV. Under the median-based IPA, the distribution changed to 1 in Quadrant I, 3 in Quadrant II, 3 in Quadrant III, and 1 in Quadrant IV. This redistribution reflects the lower median cutoffs, which reclassified one category into the high-importance/high-performance quadrant and shifted two categories out of Quadrant IV. Even so, the broader structure of the IPA remained interpretable: LT and EQ continued to appear as high-importance/low-performance priorities, RP and IN remained in the high-performance/low-importance region, and SS remained in the low-priority quadrant.

Table 3. Quadrant counts

Quadrant	**Mean-based**	**Median-based**
I. Keep up the good work	0	1
II. Concentrate here	3	3
III. Possible overkill	2	3
IV. Low priority	3	1

To clarify the nature of the reclassifications, Table 4 presents an IPA transition matrix. The matrix shows one transition from Quadrant II to Quadrant I (EA), one transition from Quadrant IV to Quadrant II (MR), and one transition from Quadrant IV to Quadrant III (WE). All other categories remained in their original quadrants. Thus, while the quadrant assignments are not perfectly invariant to the use of median-based thresholds, the results still support the overall usefulness of the mean-based IPA for identifying strategic improvement priorities. The robustness check should therefore be interpreted as indicating moderate stability, rather than complete stability, in the quadrant structure.

Table 4. IPA Transition Matrix (Mean → Median)

From → To	I	II	III	IV
I	0	0	0	0
II	1	2	0	0
III	0	0	2	0
IV	0	1	1	1

Figure 2 summarizes the quadrant transitions observed when the IPA cutoffs were changed from mean-based to median-based values. This figure shows that Quadrant III was fully stable, with both IN and RP retaining their original classification. Quadrant II exhibited partial stability, as LT and EQ remained unchanged, while EA shifted to Quadrant I under the lower median performance cutoff. Quadrant IV was the most sensitive quadrant, retaining only SS, while MR moved to Quadrant II and WE moved to Quadrant III. Because no category was located in Quadrant I under the mean-based IPA, this quadrant is shown as newly populated rather than as a stable quadrant. Overall, the figure indicates moderate quadrant stability, with the principal IPA structure preserved but with noticeable sensitivity among categories positioned near the original cutoff boundaries.

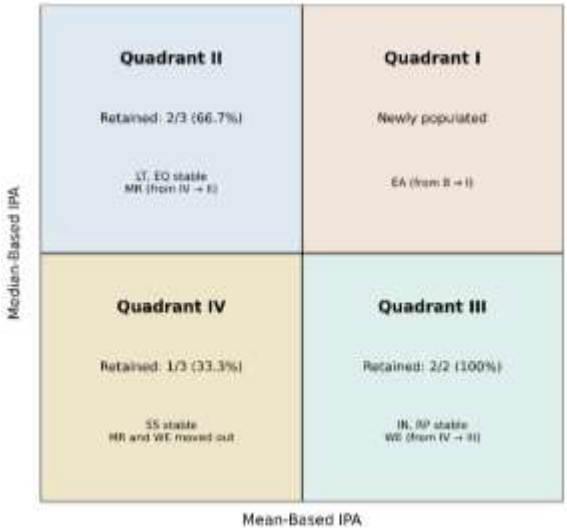

Figure 2. Visual quadrant stability summary (Mean vs. Median cutoffs)

Discussion

The Importance-Performance Analysis of 1,344 LEED v4 New Construction certified projects revealed clear strategic patterns in credit-category performance relative to importance within the LEED framework. Three categories, Location and Transportation, Energy and Atmosphere, and Indoor Environmental Quality, emerged as high importance but underperforming areas, indicating substantial opportunities for improvement. These findings align closely with trends identified in existing research, such as Goodarzi and Garshasby (2024), demonstrating that EA has the strongest influence on total LEED v4 NC scores, confirming its strategic weight in certification outcomes. In contrast, Sustainable Sites, Water Efficiency, and Materials and Resources exhibited both low

importance and low performance, while Innovation and Regional Priority demonstrated high performance in lower-importance domains. The robustness analysis indicated moderate stability in the IPA classifications, with three quadrant changes under the median-based thresholds: EA moved to 'Keep Up the Good Work,' MR moved to 'Concentrate Here,' and WE moved to 'Possible Overkill.

The underachievement of LT, despite its relatively high importance within the LEED v4 scorecard, likely reflects constraints that extend beyond the immediate control of individual project teams. LT credits are strongly influenced by urban form, regional infrastructure, and site availability, factors that are largely predetermined at the time of project inception. Prior research has shown that LEED projects located in suburban or auto-oriented contexts face structural barriers to achieving transit access, density, and connectivity credits, even when project teams prioritize sustainability objectives (Ahmad et al., 2025). As a result, LT performance may systematically lag its weighting, not due to lack of strategic intent, but because certification frameworks assign substantial importance to conditions shaped by broader planning and market forces rather than project-level design decisions.

In contrast, the placement of Innovation and Regional Priority in the "Possible Overkill" quadrant suggests a different mechanism rooted in certification strategy rather than external constraint. Both categories are characterized by comparatively low point values, flexible achievement pathways, and high predictability. Prior studies have documented that project teams often pursue such credits to secure reliable points through standardized documentation templates, exemplary performance extensions, or regionally pre-aligned criteria (Goodarzi et al., 2023). The consistently high performance of IN and RP, therefore, is likely to reflect ease of attainment and risk minimization behavior, rather than disproportionate sustainability impact.

Taken together, these patterns reinforce the IPA interpretation of strategic misalignment: categories with the greatest theoretical leverage over sustainability outcomes (LT, EA, EQ) face either structural constraints or higher technical uncertainty, while lower-impact categories offer accessible certification gains. This asymmetry helps explain why performance does not scale proportionally with importance across the LEED v4 framework and underscores the need to distinguish between controllable and context-dependent credit domains when interpreting certification outcomes. The concentration of LT, EA, and EQ in the "Concentrate Here" quadrant, therefore, mirrors both empirical and practical realities; these categories are vital to overall building sustainability but remain under-realized in practice. Moreover, the placement of IN and RP in the "Possible Overkill" quadrant supports earlier findings by Ma & Cheng (2016) that project teams often pursue easier or lower-impact credits to secure certification gains.

Implications for the construction industry and body of knowledge

Collectively, the results of this study offer both theoretical and applied insights. For practitioners, the IPA highlights where targeted efforts can yield the greatest improvements: enhancing performance in energy efficiency, transportation access, and indoor environmental quality can maximize LEED outcomes and actual sustainability impact. Conversely, overemphasis on less influential categories like IN and RP may divert resources from high-impact strategies.

From a practical standpoint, the results suggest a tactical roadmap for project teams, developers, and certification strategies. Since LT, EA, and EQ are the credit categories with high strategic importance but underperformance, project teams aiming to elevate certification levels or improve sustainability outcomes should prioritize resources and attention in these domains. For example, improved design integration for site selection and transportation connectivity (LT), rigorous energy modelling,

commissioning, and post-occupancy validation (EA), and robust indoor environmental quality strategies with occupant-centric monitoring (EQ) offer the greatest potential return in the LEED NC score structure. Similarly, the finding that SS, WE, and MR appear in the "Low Priority" quadrant does not mean they are unimportant, but rather that, within the LEED v4 NC point-structure and observed performance, they have less strategic leverage. For owners or design teams constrained by budget or schedule, emphasis might shift from attaining the numerous low-impact credits to focusing on the fewer high-leverage ones.

From an industry perspective, the results highlight a continuing performance gap between the importance of energy and environmental quality outcomes and their actual achievement levels across certified projects. This reinforces that the transition from design intent to verified performance remains a challenge in sustainable building delivery, as suggested in an empirical review by Leite Ribeiro et al. (2025) showing persistent discrepancies between predicted and measured energy use in LEED-certified buildings. Aligning project effort with these high-importance but underperforming categories could help narrow that gap. Accordingly, the IPA results should be interpreted as diagnosing alignment within the certification process itself, while existing evidence on certification–operation performance gaps suggests that underachievement in high-importance categories such as EA and EQ may also contribute to persistent discrepancies between design intent and in-use outcomes.

From a construction management standpoint, this study offers actionable guidance. Project teams frequently balance constraints of cost, schedule, and certification level. The IPA framework provides a quantitative, evidence-based approach to decision-making, enabling teams to allocate effort and resources toward the credit categories that have the greatest impact on both certification success and sustainability outcomes. The results encourage practitioners to shift resources away from overachieved, low-impact credits to intensify technical focus on the underperforming yet high-impact categories. For certifying bodies and policy developers, these insights may inform adjustments to point weighting, guidance documents, or incentive mechanisms to promote better alignment between project behaviors and environmental outcomes.

Conclusion

This study provides a comprehensive, data-driven assessment of the strategic relationship between credit-category importance and achievement performance in LEED v4 NC projects. The results confirm that energy performance, location efficiency, and indoor environmental quality remain the most critical yet underachieved domains within the LEED framework. These findings carry practical significance for design teams, owners, and policymakers seeking to enhance the effectiveness and credibility of green-building certification.

A key limitation of this study is that it evaluates performance strictly within the LEED certification framework, using achieved points as indicators of relative category performance, rather than measured post-occupancy outcomes such as actual energy use, water consumption, or occupant satisfaction. As documented extensively in the literature, LEED certification does not consistently translate into verified operational performance, particularly in energy-related domains. Consequently, the IPA results should be interpreted as reflecting strategic alignment, or misalignment, within certification behavior, not as direct evidence of real-world environmental or operational effectiveness.

This distinction is particularly relevant for high-importance categories such as Energy and Atmosphere and Indoor Environmental Quality, where documented gaps between design intent and in-use performance are common. While the IPA identifies these categories as underachieved relative

to their weighting, the analysis does not capture whether projects that score highly within these categories ultimately deliver superior operational outcomes. As such, the findings inform how project teams allocate effort within the LEED scorecard, but not how effectively those efforts translate into long-term sustainability performance. Recognizing this limitation strengthens the interpretation of the results: the observed importance–performance imbalance highlights strategic tendencies within certification practice rather than deficiencies in building operation per se. Future research integrating post-occupancy performance data with certification-based IPA would be necessary to directly assess whether misalignment at the certification stage propagates into measurable performance gaps in use.

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