Article

Not peer-reviewed version

Leadership in Energy and Environmental Design for Existing Buildings Version 4.1 (LEED-EB v4.1) Gold-Certified Office Space Projects in European and Mediterranean Countries: A Pairwise Comparative Analysis

Svetlana Pushkar *

Posted Date: 15 July 2025

doi: 10.20944/preprints202507.1228.v1

Keywords: LEED-EB v4.1; Europe; the Mediterranean

Article

Leadership in Energy and Environmental Design for Existing Buildings Version 4.1 (LEED-EB v4.1) Gold-Certified Office Space Projects in European and Mediterranean Countries: A Pairwise Comparative Analysis

Svetlana Pushkar

Department of Civil Engineering, Ariel University, Ariel 40700, Israel; svetlanap@ariel.ac.il

Abstract

Abstract: This study aims to focus on LEED for Existing Buildings version 4.1 (LEED-EB v4.1) gold-certified office projects. Cliff's δ and exact Wilcoxon–Mann–Whitney tests were used to conduct a pairwise comparison of six countries (Sweden, Ireland, Germany, Spain, Italy, and Israel) in terms of five performance indicators (transportation, water, energy, waste, and indoor environmental quality). As a result, Sweden and Germany outperformed Italy (p = 0.002 and 0.018, respectively) in transportation performance. Ireland outperformed Italy and Israel (p = 0.015 and 0.032, respectively) and Germany outperformed Italy and Israel (p =0.003 and 0.009, respectively) in water performance. Germany outperformed Sweden, Ireland, and Israel (p <0.001, respectively) and Sweden, Spain, and Italy outperformed Israel (p <0.001, p = 0.008, and p = 0.009, respectively) in energy performance. Italy outperformed Sweden, Ireland, Germany, and Israel ($0.001 < p \leq 0.013$) and Spain outperformed Germany and Israel (p = 0.015 and p <0.001, respectively) in waste performance. Israel outperformed Sweden, Germany, and Italy (p <0.001, p <0.001, and p = 0.006, respectively) and Spain, Ireland, and Italy outperformed Sweden (p <0.001, p = 0.002, and p = 0.004, respectively) in indoor environmental quality performance. Thus, the LEED certification strategy is "country-specific".

Keywords: LEED-EB v4.1; Europe; the Mediterranean

---

1. Introduction

The Leadership in Energy and Environmental Design (LEED) rating system was launched in 1998 by the U.S. Green Building Council to reduce the environmental impact of the U.S. building sector [1]. LEED has now become the most widely accepted and studied building green rating system worldwide [2,3] and in Europe [4].

It has been suggested [5] that each subsequent LEED version (v)—v1 (2000), v2.2 (2005), v3 (2009), v4 (2013), and v4.1 (2019)—may implement a more flexible LEED certification strategy and, as a result, may reduce environmental harm. In this paper, the literature review section focuses primarily on LEED v3 and v4 because the difference between LEED certification strategies in each version was assessed using inferential statistics.

Table 1 lists the LEED systems and LEED versions whose LEED-certified projects were used for comparisons between world regions, between countries from different regions, and between countries in the same region.

Table 1. Leadership in Energy and Environmental Design (LEED) sub-systems, versions 3 and 4.

Acronym	The Full Form
LEED-CI v3	LEED Commercial Interior versions 3 and 4

 doi:10.20944/preprints202507.1228.v1

LEED-CI v4 LEED-C-and-S v3 LEED-C-and-S v4	LEED Core and Shell Development versions 3 and 4
LEED-EB v3 LEED-EB v4	LEED for Existing Buildings versions 3 and 4

The above-mentioned LEED systems, v3 and v4, contain the following categories: sustainable sites (SS), water efficiency (WE), energy and atmosphere (EA), materials and resources (MRs), indoor environmental quality (EQ), regional priority category (RP), and innovation in design (ID); by contrast, v4 includes an additional location and transportation (LT) category, which has been separated from SS [6,7].

This study focuses on the LEED-EB v4.1 system, which includes interval data in five LEED credits and binary data in ten LEED credits [8].

The LEED-EB v4.1 system is completely different from the previous LEED-EB v2.2, v3, and v4 systems. This is because LEED-EN v4.1 focuses on performance-based prerequisites that are mandatory requirements for LEED certification. This system, in addition to the water and energy savings performance-based prerequisites in WE and EA (which already existed in LEED v2.2, v3, and 4), introduced for the first time performance-based prerequisites for LT, MR, and EQ. Thus, LEED-EB v4.1 prioritizes five performance-based prerequisites, LT, WE, EA, MRs, and EQ, encouraging measurements based on a project's performance over a specified period of 1 year (365 consecutive days). This is because certification strategies for LEED-EB v4.1-certified projects may differ from certification strategies for LEED v3 and 4-certified projects and therefore require special consideration.

Table 2 lists five main performance-based prerequisites with maximum points in the LEED-EB v4.1 system. It should be noted that the sum of these prerequisites can reach 90 points.

Table 2. LEED-EB v4.1 rating system: performance-based prerequisites with maximum points (interval scale).

Category	Prerequisite	Maximum Points
Location and transportation (LT)	LT, Transportation performance	14
Water efficiency (WE)	WE, Water performance	15
Energy and atmosphere (EA)	EA, Energy performance	33
Materials and resources (MR)	MRs, Waste performance	8
Indoor environmental quality (EQ)	EQ, Indoor environmental quality performance	20
Total		90

Table 3 lists ten additional binary credits.

Table 3. LEED-EB v4.1 rating systems: credits with maximum points (binary scale).

Category	Credit	Maximum Points
Sustainable sites (SS)	SSc1, Rainwater management	1
	SSc2, Heat island reduction	1
	SSc3, Light pollution reduction	1
	SSc4, Site management	1
Energy and atmosphere (EA)	EAc1, Enhanced refrigerant management	1
	EAc2, Grid harmonization	1
Materials and resources (MR)	MRc1, Purchasing	1
Indoor environmental quality (EQ)	EQc1, Green cleaning	1
	EQc2, Integrated pest management	1
Innovation (IN)	INc1, Innovation	1
Total		10

It is worth noting that these ten binary credits had less than 1% scores in LEED-EB v4.1 gold-certified office projects. Therefore, LEED-EB v4.1 binary credits were not analyzed in this study.

 doi:10.20944/preprints202507.1228.v1

In 2020, the importance of using the LEED-EB v4.1 system in the Mediterranean region was highlighted. Laera and de Pereda Fernández [9] noted in an editorial that certifying existing buildings to the LEED-EB v4.1 standard is considered one of the most effective strategies in terms of energy savings and emission reduction in Spain. El Sorady and Rizk [10] reported on the successful application of the LEED-EB v4.1 system to Islamic buildings in historic Cairo. However, LEED-EB v4.1-certified projects have not yet been evaluated through comparisons between independent groups (e.g., between countries) using inferential statistics.

2. Literature Review

2.1. Statistical Criteria for Comparative Analysis

This literature review includes a pairwise comparison of LEED-certified projects between the following regions: North America, East Asia, West Asia, and Europe; between European countries; and between Mediterranean countries. To interpret the results of the literature review, the following statistical indicators were used: sample size (n), p-value, and Cliff's δ effect size.

Because LEED data contain interval data with low variability and a certain amount of "tied" data, the minimum sample size required to obtain a reliable conclusion is $n_1 = n_2 \geq 12$ [11]. In this study, I used three-valued logic to interpret the p-value "it seems to be positive" (i.e., there seems to be a difference between countries), "it seems to be negative" (i.e., there does not seem to be a difference between the two countries), and "judgment is suspended" regarding the difference between the two countries without fixing the significance level (e.g., $\alpha = 0.05$) instead of dichotomizing the decision for p-values, $p \leq \alpha$ or $p > \alpha$, at a fixed level of α [12,13]. To interpret Cliff's δ size effect, the following four decision levels were used: (i) negligible if $|\delta| < 0.147$, (ii) small if $0.147 \leq |\delta| < 0.33$, (iii) medium if $0.33 \leq |\delta| < 0.474$, and (iv) large if $|\delta| \geq 0.474$ [14]. It should be noted that effect size is a general rule of thumb rather than a strict criterion, especially when little knowledge has accumulated [15,16].

2.2. Pairwise Comparison Worldwide

Wu et al. [17] used significance tests to compare different regions such as North America, East Asia, West Asia, and Europe in terms of LEED v2.2- and LEED v3-certified projects at the category level (total sample size = 5327). Wu et al. [18] used significance tests to compare differences between adjacent certification levels across the world: Certified and Silver, Silver and Gold, and Gold and Platinum (total sample size = 3416). In both studies, the statistical difference between independent groups was associated with a low p-value. However, the combination of large sample size and low p-value can sometimes be associated with a small or negligible effect size [19].

Chi et al. [20] used both p-value and effect size to compere the USA and China in terms of construction waste minimization (CWM) performance for LEED-NC v3 2009-certified projects. They found that the difference between the USA (n = 190) and China (n = 147) in terms of CWM performance showed $p = 0.011$ when the sample size was related to the transition zone between a negligible and a small effect size of $\delta = 0.148$ (i.e., the bounds for a small effect size were δ = 0.147–0.32).

Pushkar [21] also used both p-value and effect size to compare the USA (n = 36) with China (n = 38) in terms of LEED-CI gold-certified projects. The author of this paper showed, for example, that for LEED-CI v4 gold-certified projects, China outperformed the USA with a large effect size in the LT category, while the USA outperformed China with a large effect size in the EA category ($p = 0.0001$ and $\delta = 0.54$, and $p = 0.0001$ and $\delta = 0.53$, respectively; i.e., the lower bound for a large effect size was $\delta = 0.474$).

2.3. Pairwise Comparison in European and Mediterranean Countries

The literature review of the following five studies focused on LEED-certified projects from different LEED systems and LEED versions. A common limitation of these three studies [22,23,24] is that LEED-certified projects were analyzed without regard to the type of space in the building. The fourth and fifth studies [25,26] considered the type of space in the building when analyzing LEED-certified projects.

2.3.1. Using p-Value Without Taking Effect Size and Building Type into Account

Pushkar [22] studied the LEED–NC v3 2009 system through comparison between Northern and Southern European countries in terms of LEED–NC v3 gold-certified projects. Northern Europe was represented by Finland (n = 15) and Sweden (n = 23), while Southern Europe was represented by Türkiye (n = 73) and Spain (n = 22).

Below are three comparative analyses between Northern and Southern Europe, between Nordic countries, and between Southern European countries in LEED–NC v3 2009 gold-certified projects:

- Northern European countries outperformed Southern European countries in the "optimize energy performance" credit (p = 0.016);
- Sweden outperformed Finland in the "water efficient landscaping" credit (p = 0.013), while Finland outperformed Sweden in the "water use reduction" credit (p = 0.028);
- Sweden outperformed Finland and Türkiye outperformed Spain in the "recycled content" credit (p = 0.005 and 0.001, respectively).

Pushkar [23] studied the LEED–C-and–S v3 and v4 systems through comparisons between Finland (n = 11) and Spain (n = 11) in terms of LEED–C-and-S v3 and v4 gold-certified projects. Below are two comparative analyses of similar LEED credits in terms of LEED–C-and-S v3 and v4 gold-certified projects:

- Finland outperformed Spain in the "optimize energy performance" credit in both v3 and v4 (p = 0.0003 and 0.0006, respectively);
- Spain outperformed Finland in the "materials and resources" category in v3 and no statistical difference was found in v4 (p = 0.0027 and 0.1313, respectively).

Pushkar [24] studied the LEED–CI v3 and LEED–C-and-S v3 systems through pairwise comparisons between Türkiye, Spain, and Italy in terms of LEED–CI v3 and LEED–C-and-S v3 gold-certified projects. LEED–CI v3 gold-certified projects were collected in Türkiye (n = 10), Spain (n = 13), and Italy (n = 8) and LEED–C-and-S v3 gold-certified projects were collected in Türkiye (n = 37), Spain (n = 22), and Italy (n = 18).

Below are three comparative analyses of similar LEED credits in LEED–CI v3 gold-certified projects and five comparative analyses of similar LEED credits in LEED–C-and-S v3 gold-certified projects.

LEED–CI v3 gold-certified projects:

- Türkiye outperformed Spain in the "site selection" credit (p = 0.007) and Türkiye outperformed Italy in the "water use reduction" credit (p = 0.030).
- Italy and Spain outperformed Türkiye in the "optimize energy performance–HVAC" credit (p = 0.042 and 0.061, respectively);
- Spain and Italy outperformed Türkiye in the "construction waste management" credit (p = 0.008 and 0.063, respectively).

LEED–C-and-S v3 gold-certified projects:

- Spain outperformed Türkiye in the "water efficient landscaping" and the "water use reduction" credits (p = 0.025 and 0.010, respectively);
- Italy outperformed Türkiye and Spain in the "optimize energy performance" credit (p = 0.004 and 0.053, respectively);
- Spain and Italy outperformed Türkiye in the "on-site renewable energy" credit (p = 0.001 in both comparisons);
- Italy outperformed Türkiye and Spain in the "building reuse–maintain existing walls, floors and roof" credits (p = 0.001, in both comparisons);
- Türkiye and Italy outperformed Spain in the "measurement and verification–base building" and the "recycled content" credit (p = 0.001 and <0.001, respectively).

 doi:10.20944/preprints202507.1228.v1

2.3.2. Using p-Value and Effect Size, Taking Building Type into Account

Pushkar [25] studied the LEED-EB system in v3 and v4 through pairwise comparisons between Finland and Spain in terms of LEED-EB v3 and v4 gold-certified office projects. LEED-EB v3 gold-certified office-type projects were collected in Finland (n = 14) and Spain (n = 16). LEED-EB v4 gold-certified office-type projects were collected in Finland (n = 14) and Spain (n = 16).

Below are three comparative analyses of similar LEED credits between LEED-EB v3 and v4 gold-certified office projects:

- Spain outperformed Finland in the "alternative commuting transportation" credit in v3 (p = 0.0001, δ = 0.79), while a statistical difference was found between Spain and Finland in the "alternative transportation" in v4 (p = 0.0940, δ = 0.35).
- Finland outperformed Spain in the "water efficient landscaping" (p = 0.00002, δ = 0.81) in v3, while a statistical difference was found between Finland and Spain in the "outdoor water use reduction" credit in LEED-EB v4 (p = 0.0613, δ = 0.31).
- No statistical difference was found between Finland and Spain in both the "optimize energy efficiency performance" credit in v3 and the "optimize energy performance" credit in v4 (p = 0.4976 and δ = 0.14, and p = 0.1129 and δ = 0.33, respectively).

Pushkar [26] studied the LEED–CI v4 system through pairwise comparisons between Spain (n = 14), Türkiye (n = 13), and Israel (n = 11) in terms of LEED-CI v4 gold-certified office projects. Below are three comparative analyses of similar LEED credits between LEED-EB v3 and v4 gold-certified office projects:

- Israel outperformed Spain in the "optimize energy performance" credit (p = 0.055, δ = 0.45) and no statistical difference was found between Spain and Türkiye and between Türkiye and Israel in the "optimize energy performance" credit (p = 0.710 and δ = 0.09, and p = 0.211 and δ = 0.31, respectively);
- Spain outperformed Türkiye and Israel in the "interiors life-cycle impact reduction" credit (p = 0.032 and 0.037, respectively);
- Türkiye and Spain outperformed Israel in the "reduced parking footprint" credit (p = 0.001 and δ = 0.76, and p = 0.008 and δ = 0.58, respectively).

2.4. Research Gap

A comparative analysis was used to estimate the difference in LEED certification strategies in terms of LEED v.2, v3, and v4 (the latest versions at the time) with the required sample sizes in LEED-NC-, LEED-C-and-S-, LEED-EB-, and LEED-CI-certified projects to conduct the significance test. A comparative analysis showed that each new LEED version and each LEED system had a difference in LEED certification strategies.

In 2024, Pushkar [26] used the comparative analysis to compare three Mediterranean countries, Spain, Türkiye, and Israel, in terms of LEED-CI v4 gold-certified office projects. This study is the closest analog to the current study.

Currently, a pairwise comparison between Sweden, Ireland, Germany, Spain, Italy, and Israel in terms of LEED-EB 4.1 gold-certified office projects has not yet been conducted.

2.5. Purpose of this Study

The aim of this study is to conduct a pairwise comparison of six countries from different regions of Europe and the Mediterranean in terms of LEED-EB v4.1 gold-certified office building projects. It should be noted that LEED-EB v4.1 is the latest version with the required sample sizes for each of these countries to conduct the significance test for pairwise comparisons.

2.6. The Contribution and Novelty

This study's findings should help LEED certification professionals understand how to reduce the environmental impact of the building sector by better defining LEED-EB v4.1 office building

 doi:10.20944/preprints202507.1228.v1

certification strategies at the gold certification level in specific European and Mediterranean countries.

This study is the first to compare LEED-EB v4.1 gold-certified projects from six European and Mediterranean countries using inferential statistics.

3. Materials and Methods

3.1. Flowchart of Present Study

The flowchart of the present study contains the following two sections: data collection and data analysis.

Data collection:

- We collected LEED-EB v4.1-certified office projects in twenty countries;
- We selected six countries that have an acceptable number of LEED-EB v4.1 gold-certified office projects to draw reliable statistical conclusions.

Data analysis:

A pairwise comparative analysis:

- We compared six selected countries in terms of LEED-EB v4 gold-certified office projects using descriptive and inferential statistics;
- We used three-valued logic for p-values to interpret different LEED certification strategies in LEED-EB v4.1 gold-certified office projects.

Data collection and data analysis are presented in Sections 3.2 and 3.3, respectively.

3.2. Data Collection

3.2.1. A Minimum Sample Size

Pushkar [11] showed that LEED data contain interval data with low variability and with a certain amount of "tied" data. In this context, the use of significance tests requires the following two conditions to be met: (1) use the nonparametric exact Wilcoxon–Mann–Whitney (WMW) test instead of the parametric t-test when comparing two independent groups, and (2) use a sample size (n) of $n_1 = n_2 \geq 12$ to obtain reliable inferential conclusions [27]. Bergmann et al. [27] explained the need to use the exact WMW test instead of the normal approximation in the presence of "tied" data.

Table 4 lists twenty countries from European and Mediterranean countries where at least one LEED-EB v4.1 project was certified in both the U.S. Green Building Council (USGBC) and the Green Building Information Gateway (GBIG) databases [28,29]. It should be noted that the bold font style indicates the number of LEED projects that were accepted to estimate using inferential statistics.

Table 4. The distribution of the number of LEED-EB v4.1-certified office projects in several European and Mediterranean countries (in alphabetical order) across the four LEED certification levels (May 3, 2025).

Country	Certified	Silver	Gold	Platinum
Egypt	0	0	1	0
Finland	0	0	6	0
France	0	0	1	0
Germany	0	0	**24**	2
Greece	0	0	3	0
Hungary	0	0	1	0
Ireland	0	0	**15**	0
Israel	0	0	**18**	0
Italy	0	0	**24**	0
Latvia	0	0	1	0

 doi:10.20944/preprints202507.1228.v1

Poland	0	0	3	1
Portugal	0	0	2	0
Romania	0	0	10	7
Serbia	0	0	11	0
Slovakia	0	0	4	0
Spain	0	0	**23**	10
Sweden	0	6	**36**	0
Türkiye	0	0	7	4
Ukraine	0	0	0	1
United Kingdom	0	0	1	0

3.2.2. Normality Assumption

Table 5 shows that the normality assumption was not met for three or four of the five variables (five LEED-EB v4.1 credits) in LEED-EB v4.1 gold-certified office projects in six countries.

Table 5. Results of the Shapiro–Wilk normality test for LEED-EB v4.1 gold-certified office projects in six countries.

Country	Prerequisite	*p*-Value
Sweden	Transportation performance	<0.001
	Water performance	0.002
	Energy performance	0.220
	Waste performance	<0.001
	Indoor environmental quality performance	0.025
Ireland	Transportation performance	<0.001
	Water performance	0.019
	Energy performance	0.485
	Waste performance	0.001
	Indoor environmental quality performance	0.088
Germany	Transportation performance	<0.001
	Water performance	0.044
	Energy performance	0.015
	Waste performance	0.204
	Indoor environmental quality performance	0.048
Spain	Transportation performance	0.007
	Water performance	0.132
	Energy performance	0.012
	Waste performance	0.010
	Indoor environmental quality performance	0.098
Italy	Transportation performance	0.023
	Water Performance	0.299
	Energy Performance	0.026
	Waste Performance	0.001
	Indoor Environmental Quality Performance	0.069
Israel	Transportation performance	<0.001
	Water performance	0.191
	Energy performance	0.830
	Waste performance	0.017
	Indoor environmental quality performance	0.005

Therefore, nonparametric descriptive and inferential statistics were used for pairwise comparisons between the six countries.

3.3. Data Analysis

The median and 25–75th percentiles, two-tiled p-value, and Cliff's δ effect size tests were used to estimate pairwise comparisons between the six selected countries.

According to [12,13], three-valued logic was used to interpret the *p*-value regarding the difference between two groups: "it seems to be positive" (i.e., there seems to be a difference between two groups), "it seems to be negative" (i.e., there does not seem to be a difference between two groups), and "judgment is suspended".

According to [30], 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's δ [30] is expressed as

$$\delta = \#(x_1 > x_2) - \#(x_1 < x_2)/(n_1 n_2) \quad (1)$$

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, groups 1 and 2; and # indicates the number of times.

According to Romano et al. [14], Cliff's δ effect size has four levels of practical significance.

Table 6 shows four levels of Cliff's δ effect size.

Table 6. Cliff's δ effect size in absolute value.

Negligible	Small	Medium	Large	Reference
$\lvert\delta\rvert < 0.147$	$0.147 \le \lvert\delta\rvert < 0.33$	$0.33 \le \lvert\delta\rvert < 0.474$	$\lvert\delta\rvert \ge 0.474$	[14]

Wolker [15] and Durlak [16] noted that effect size is a general rule of thumb rather than a strict criterion, especially when little knowledge has accumulated.

3.4. The Relationship Between p-Value and Effect Size

Historically, the *p*-value has been used to make a dichotomous decision, a significant difference if $p \le 0.05$ or no significant difference if $p > 0.05$, at a significance level of $\alpha = 0.05$ [12]. However, Fisher philosophically noted that "no scientific worker has a fixed level of significance at which from year to year, and in all circumstances, he rejects (null) hypotheses; he rather gives his mind to each particular case in light of his evidence and ideas" [31], as cited by [12]. Beninger et al. [32] noted that dichotomizing the scale of the *p*-values, i.e., $p \le \alpha$ or $p > \alpha$, cannot be used as a sort of mechanical Occam's razor. Furthermore, Altman [33] noted that it is absurd to interpret the results of a study differently depending on whether the *p*-value obtained was, say, 0.055 or 0.045. Additionally, Hurlbert and Lombardi [12] cited the recommendation of Gotelli and Ellinson [34], 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". Kennedy-Shaffer [35] noted that a balanced decision must be made by considering statistical significance (*p*-value) and substantive significance (effect size) in parallel. Hurlburt and Lombardi [12] argue that making decisions based on *p*-value and effect size results should also include a review of the literature and the author's experience.

4. Results and Discussion

4.1. Prerequisite LT: Transportation Performance

Prerequisite LT: Transportation performance requires a one-week survey of building occupant traffic flows once a year. This measure is the project's average CO_2 emissions per trip per occupant, which is then translated into a transportation score and ultimately LEED points. This LEED-EB v4.1 performance presents CO_2 emission values for each transport mode: from 0.26, 0.33, 0.39, 0.44, 0.68,

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 15 July 2025 doi:10.20944/preprints202507.1228.v1

and 0.93 for motorcycle, heavy rail, carpool, alternative fuel vehicles, bus, and convenient car, respectively [8]. Thus, a more sustainable mode of transport and a shorter traffic flow result in more LEED points.

In this respect, Table 7 shows that, for this prerequisite, Sweden and Germany outperformed Italy (the difference seems to be positive; $p = 0.002$ and 0.018, respectively). The difference between the remaining 13 pairwise comparisons seems to be negative ($p \geq 0.070$).

Table 7. Prerequisite LT: Transportation performance of LEED-EB v4.1 gold-certified office projects in six countries: Sweden, Ireland, Germany, Spain, Italy, and Israel.

Prerequisite (max points)	**Sample Size (n), Median, 25–75th Percentiles**					
	Sweden (n = 36)	**Ireland (n = 15)**	**Germany (n = 24)**	**Spain (n = 23)**	**Italy (n = 24)**	**Israel (n = 18)**
LT: Transportation Performance (14)	13.0, 12.0–13.0	12.0, 12.0–13.0	13.0, 12.0–13.0	11.0, 10.2–13.0	11.5, 10.0–12.5	12.0, 12.0–12.0
	p-value (Cliff's δ)					
	Sweden	Ireland	Germany	Spain	Italy	Israel
Sweden	X	0.362 (0.15)	0.856 (0.03)	0.076 (0.26)	**0.002** (0.44)	0.070 (0.28)
Ireland		X	0.499 (-0.12)	0.536 (0.12)	0.128 (0.28)	0.517 (0.13)
Germany			X	0.201 (0.21)	**0.018** (0.38)	0.177 (0.24)
Spain				X	0.440 (0.13)	0.704 (-0.07)
Italy					X	0.240 (-0.21)
Israel						X

Note: The p-values were evaluated according to three-valued logic: font style is bold—seems to be positive; font size is ordinal—seems to be negative; and font style is italic—judgment is suspended.

The most projects were certified in large cities such as Gothenburg (10 projects) and Stockholm (8 projects) (Sweden), Dublin (15 projects) (Ireland), Berlin (12 projects) and Hamburg (6 projects) (Germany), Barcelona (10 projects) and Madrid (10 projects) (Spain), Milano (19 projects) (Italy), and Tel Aviv (8 projects) (Israel) (Appendix A, Table A1). All of these cities have well-developed public transportation systems [36]. Therefore, the median LEED scores were near the maximum (11.0–13.0) in all of these countries.

The results of previous studies support the findings of this prerequisite. According to Dolge [36], among 28 European countries, the share of public transport, as well as the share of alternative fuel vehicles such as electric vehicles, in total passenger transport is much higher in Sweden, Ireland, and Germany than in Spain and Italy. Mandev and Sprei [37] measured the share of electrified kilometers of plug-in hybrid electric vehicles in total passenger turnover in 10 European countries and found that it was higher in Sweden, Germany, and Spain than in Italy.

4.2. Prerequisite WE: Water Performance

Prerequisite WE: Water performance requires a monthly measurement of total potable water consumption for one full year. Based on these data, it is necessary to calculate the water consumption in the project per resident and per unit area. These water consumptions are then used to obtain a water performance score. Ultimately, LEED-EB v4.1 points are awarded based on the water performance score: a higher water performance score results in a higher LEED-EB v4.1 points [8].

In this respect, Table 8 shows that, for this prerequisite, Ireland and Germany outperformed Italy and Israel (the difference seems to be positive, $p = 0.015$ and 0.032 and $p = 0.003$ and 0.009, for Ireland and Germany, respectively). Germany also outperformed Spain (the difference seems to be positive, $p = 0.028$). The judgment is suspended regarding the difference between Sweden and Germany and between Sweden and Italy ($p = 0.051$ and 0.062, respectively). The difference between the remaining eight pairwise comparisons seems to be negative ($p \geq 0.146$).

 doi:10.20944/preprints202507.1228.v1

Table 8. Prerequisite WE: Water performance of LEED-EB v4.1 gold-certified office projects in six countries: Sweden, Ireland, Germany, Spain, Italy, and Israel.

Prerequisite (max points)	Sample Size (n), Median, 25–75th Percentiles					
	Sweden (n = 36)	**Ireland (n = 15)**	**Germany (n = 24)**	**Spain (n = 23)**	**Italy (n = 24)**	**Israel (n = 18)**
WE: Water Performance (15)	11.0, 9.0–12.0	11.0, 11.0–12.0	12.0, 10.0–13.0	10.0, 7.2–12.0	9.0, 8.0–11.0	10.0, 8.0–11.0
	p-value (Cliff's δ)					
	Sweden	Ireland	Germany	Spain	Italy	Israel
Sweden	X	0.518 (-0.11)	*0.051* (-0.30)	0.421 (0.12)	*0.062* (0.28)	0.146 (0.24)
Ireland		X	0.313 (-0.19)	0.181 (0.26)	**0.015** (0.45)	**0.032** (0.43)
Germany			X	**0.028** (0.37)	**0.003** (0.48)	**0.009** (0.46)
Spain				X	0.561 (0.10)	0.849 (0.04)
Italy					X	0.670 (-0.08)
Israel						X

Note: The p-values were evaluated according to three-valued logic: font style is bold—seems to be positive; font size is ordinal—seems to be negative; and font style is italic—judgment is suspended.

However, for all of these countries, the median LEED-EB v4.1 points was not that close to the maximum allowed: 11.0 or 12.0 for Sweden, Ireland, and Germany and 9.0 or 10.0 for Spain, Italy, and Israel. In Sweden, half of the drinking water comes from surface water and the other half from natural groundwater. However, according to interviews with local municipalities in Sweden, citizens are not aware of or interested in saving drinking water [38]. In Ireland, given the droughts, the need for water conservation measures is a major issue requiring public awareness [39]. In Germany, although rainwater and greywater treatment can improve water availability in urban areas, water conservation remains an important issue [40]. Thus, higher average WE LEED-EB v4.1 scores in Sweden, Ireland, and Germany would be more desirable.

Spain, Italy, and Israel are Mediterranean countries. The region is characterized by moderate climate change, accelerated population growth, and increasing natural water scarcity. Therefore, despite the advanced water purification technologies such as desalination used in the region, especially in Israel, water conservation still remains a very important factor [41]. However, according to the results, the median LEED-EB v4.1 score in these countries was only 9.0 or 10.0 out of a possible 15.

4.3. Prerequisite EA: Energy Performance

Prerequisite EA: Energy performance requires monthly measurement of the total energy consumption of the project for one full year. The measured energy consumption is then converted into equivalent project greenhouse gas (GHG) emissions and source energy consumption per occupant and per unit area. After that, GHG emissions are converted into a GHG emissions score, and source energy consumption is converted into a source energy score. Ultimately, the sum of the 50% GHG gas emission score and 50% energy source score determines the EA LEED-EB v4.1 points [8].

Table 9 shows that, for this prerequisite, Germany outperformed Sweden, Ireland, and Israel, and Sweden outperformed Israel (the difference seems to be positive, p <0.001 for all cases). Spain and Italy outperformed Israel (the difference seems to be positive, $p = 0.008$ and 0.009). The judgment is suspended regarding the difference between Germany and Italy ($p = 0.068$). The difference between the remaining eight pairwise comparisons seems to be negative ($p \geq 0.078$).

Table 9. Prerequisite EA: Energy performance of LEED-EB v4.1 gold-certified office projects in six countries: Sweden, Ireland, Germany, Spain, Italy, and Israel.

	Sample Size (n), Median, 25–75th Percentiles

 doi:10.20944/preprints202507.1228.v1

Prerequisite (max points)	Sweden (n = 36)	Ireland (n = 15)	Germany (n = 24)	Spain (n = 23)	Italy (n = 24)	Israel (n = 18)
EA: Energy Performance (33)	25.0, 23.0–26.0	22.0, 21.0–25.0	27.0, 26.0–28.5	26.0, 21.0–28.0	26.0, 21.5–28.0,	21.5, 19.0–24.0
			p-value (Cliff's δ)			
	Sweden	Ireland	Germany	Spain	Italy	Israel
Sweden	X	0.081 (0.31)	**<0.001** (-0.55)	0.411 (-0.13)	0.396 (-0.13)	**<0.001** (0.54)
Ireland		X	**<0.001** (-0.74)	0.083 (-0.34)	0.078 (-0.34)	0.203 (0.26)
Germany			X	0.098 (0.28)	*0.068* (0.30)	**<0.001** (0.78)
Spain				X	0.919 (0.02)	**0.008** (0.48)
Italy					X	**0.009** (0.47)
Israel						X

Note: The p-values were evaluated according to three-valued logic: font style is bold—seems to be positive; font size is ordinal—seems to be negative; and font style is italic—judgment is suspended.

As explained, LEED points are calculated based on the sum of 50% GHG emissions points and 50% energy points. GHG emissions vary for different fuel sources used to produce energy. Fossil fuel sources are major contributors to GHG emissions, with coal accounting for the largest share of emissions, followed by oil and natural gas, while solar, wind, hydropower, and nuclear power are low emitters of GHG emissions. Thus, the cleaner the fuel source used in a particular country, and the less energy used to heat, cool and light a building, the higher the LEED-EB v4.1 score that can be achieved.

In this regard, Sweden uses about 45% of solar, wind, and hydro energy from its total energy sources, followed by Spain (23%), Ireland and Germany (20%), Italy (15%), and Israel (7%). Sweden uses the least amount of fossil fuels (coal, oil, and gas) of all energy sources (26%), followed by Spain (66%), Germany (75%), Ireland (78%), Italy (81%), and Israel (93%) (Appendix A, Table A2). Thus, the lowest average EA LEED-EB v4.1 score in Israel can be explained by the highest percentage of fossil fuels as energy sources and the lowest percentage of renewable energy sources compared to Sweden, Ireland, Germany, Spain, and Italy (Appendix A, Table A2).

The high average EA LEED-EB v4.1 scores in these European countries are also a result of the high energy saving standards/regulations applied in the European Union (EU). In particular, the European Green Deal aims to reduce greenhouse gas emissions in the EU by 55% by 2030 [42], the REPowerEU plan aims to increase renewable energy to 45% [43], and the Energy Performance of Buildings Directive (EPBD) aims to achieve a climate-neutral Europe by 2050 [44].

4.4. Prerequisite MRs: Waste Performance

Prerequisite MR: Waste performance requires measuring the total weight of waste such as glass, plastic, and paper that is generated by building occupants and the total weight of waste diverted from landfills and incinerators for one full year. The measured waste is then converted to a project equivalent of the total weight of waste generated and the total weight of waste diverted per day and per occupant. Using these waste weights, the daily non-diverted waste per occupant is estimated. Both measurements, the average daily waste generated by the project and the waste not diverted per occupant, determine the waste performance score. Ultimately, the corresponding LEED-EB v4.1 points are awarded based on the waste performance score [8]. The lower the total weight of waste generated and the less waste that is not recycled, the higher the LEED score.

Table 10 shows that, for this prerequisite, Italy outperformed Sweden, Ireland, Germany, and Israel (the difference seems to be positive, $p \leq 0.043$). Spain outperformed Sweden, Germany, and Israel (the difference seems to be positive, $p \leq 0.033$). The difference between the remaining five pairwise comparisons seems to be negative ($p \geq 0.103$).

Table 10. Prerequisite MRs: Waste performance of LEED-EB v4.1 gold-certified office projects in six countries: Sweden, Ireland, Germany, Spain, Italy, and Israel.

 doi:10.20944/preprints202507.1228.v1

Prerequisite (max points)	Sample Size (n), Median, 25–75th Percentiles					
	Sweden (n = 36)	Ireland (n = 15)	Germany (n = 24)	Spain (n = 23)	Italy (n = 24)	Israel (n = 18)
MRs: Waste Performance (8)	6.0, 5.0–7.0	6.0, 6.0–7.0	5.0, 5.0–6.0	7.0, 6.0–7.8	7.0, 6.5–8.0	5.0, 4.0–6.0
	p-value (Cliff's δ)					
	Sweden	Ireland	Germany	Spain	Italy	Israel
Sweden	X	**0.043** (-0.35)	0.432 (0.12)	**0.033** (-0.32)	**<0.001** (-0.63)	0.103 (0.27)
Ireland		X	**0.008** (0.49)	0.667 (-0.08)	**0.013** (-0.45)	**<0.001** (0.65)
Germany			X	**0.015** (-0.41)	**<0.001** (-0.70)	0.397 (0.15)
Spain				X	0.104 (-0.27)	**0.004** (0.51)
Italy					X	**<0.001** (0.78)
Israel						X

Note: The p-values were evaluated according to three-valued logic: font style is bold—seems to be positive; font size is ordinal—seems to be negative; and font style is italic—judgment is suspended.

The EU is a global leader in waste recycling and management through landfill restrictions and innovative waste collection and recycling [45]. In this regard, five of the six countries examined in this study, Sweden, Ireland, Germany, Spain, and Italy, have also been identified by other researchers as outstanding in waste management. For example, with regard to plastic waste, in the EU up to 2022, out of 23,299 articles published on this topic in 146 countries, Italy published 2,068 articles (9%), followed by Germany with 2,053 (9%) and Spain with 1,641 (7%) [46]. Furthermore, focusing on municipal waste recycling rates in the EU, Laureti et al. [47] reported Sweden and Germany as leading countries with high recycling rates and Ireland, Spain, and Italy as countries with average recycling rates.

4.5. Prerequisite EQ: Indoor Environmental Quality Performance

Prerequisite EQ: Indoor environmental quality performance requires that an occupant satisfaction survey and an indoor air quality assessment in terms of carbon dioxide (CO_2) and total volatile organic compound (TVOC) levels must be conducted at least annually. The occupant satisfaction survey results need to be converted into an occupant satisfaction score, while the indoor air quality assessment results need to be converted into a CO_2 score and a TVOC score. Lower CO_2 and TVOC levels result in higher CO_2 and TVOC scores. The human experience score is then assessed by summing 50% of the occupant satisfaction score, 25% of the CO_2 score, and 25% of the TVOC score. Ultimately, LEED-EB v4.1 points are awarded for the human experience score [8]. Higher occupant satisfaction and higher CO_2 and TVOC scores lead to higher LEED-EB v4.1 scores.

Table 11 shows that, for this prerequisite, Israel outperformed Sweden, Germany, and Italy (the difference seems to be positive, $p \leq 0.006$). Ireland, Spain, and Italy outperformed Sweden (the difference seems to be positive, $p \leq 0.002$). The judgment is suspended regarding the difference between Israel and Ireland ($p = 0.051$), between Israel and Spain ($p = 0.062$), and between Germany and Spain ($p = 0.046$). The difference between the remaining six pairwise comparisons seem to be negative ($p \geq 0.078$).

Table 11. Prerequisite EQ: Indoor environmental quality performance of LEED-EB v4.1 gold-certified office projects in six countries: Sweden, Ireland, Germany, Spain, Italy, and Israel.

Prerequisite (max points)	Sample Size (n), Median, 25–75th Percentiles					
	Sweden (n = 36)	Ireland (n = 15)	Germany (n = 24)	Spain (n = 23)	Italy (n = 24)	Israel (n = 18)
EQ: Indoor Environmental Quality Performance (20)	13.0, 11.5–13.5	15.0, 13.0–17.0	14.0, 11.5–15.0	15.0, 13.0–17.0	15.0, 12.0–16.0	16.5, 16.0–17.0
	p-value (Cliff's δ)					
	Sweden	Ireland	Germany	Spain	Italy	Israel

Sweden	X	**0.002** (-0.53)	0.192 (-0.20)	**<0.001** (-0.57)	**0.004** (-0.43)	**<0.001** (-0.89)
Ireland		X	0.170 (0.26)	0.748 (-0.06)	0.680 (0.08)	*0.051* (-0.39)
Germany			X	*0.046* (-0.34)	0.173 (-0.23)	**<0.001** (-0.65)
Spain				X	0.414 (0.14)	*0.062* (-0.34)
Italy					X	**0.006** (-0.48)
Israel						X

Note: The p-values were evaluated according to three-valued logic: font style is bold—seems to be positive; font size is ordinal—seems to be negative; and font style is italic—judgment is suspended.

Currently, more than 75% of existing buildings in the EU are old, built before the current thermal air conditioning regulations came into force. These buildings therefore have inadequately insulated building envelopes and uncontrolled ventilation rates, as well as highly volatile organic compounds (VOCs) emitted by building materials. This in turn leads to poor indoor air quality [48]. In this regard, the European Agenda identifies the retrofit of the housing stock as a key objective to minimize energy consumption in light of climate-neutral cities by 2050 [49]. Furthermore, the European Commission has published EU minimum concentration of interest (EU-LCI) values for 152 organic compounds commonly emitted by building materials [50]. Thus, four of the six countries assessed – Ireland, Italy, Spain, and Israel – achieved relatively high average EA LEED-EB v4.1 scores of 15.0–16.5 (Table 11).

4.6. Overall LEED-EB v4.1 Score

Table 12 shows that for LEED total, Ireland, Germany, and Spain outperformed Sweden and Israel (the difference seems to be positive, p <0.001). The judgment is suspended regarding the difference between Italy and Sweden (p = 0.056) and between Italy and Israel (p = 0.054). The difference between the remaining seven pairwise comparisons appears to be negative ($p \geq 0.190$).

Table 12. LEED total from LEED-EB v4.1 gold-certified office projects in six countries: Sweden, Ireland, Germany, Spain, Italy, and Israel.

Prerequisite (max points)	Sample Size (n), Median, 25–75th Percentiles					
	Sweden (n = 36)	**Ireland (n = 15)**	**Germany (n = 24)**	**Spain (n = 23)**	**Italy (n = 24)**	**Israel (n = 18)**
LEED total (100)	65.0, 62.5–69.0	70.0, 67.0–71.8	70.5, 68.0–73.0	70.0, 67.2–73.0	69.5, 63.0–71.5	64.0, 63.0–67.0
	p-value (Cliff's δ)					
	Sweden	Ireland	Germany	Spain	Italy	Israel
Sweden	X	**0.001** (-0.56)	**<0.001** (-0.53)	**<0.001** (-0.57)	*0.056* (-0.29)	0.543 (0.10)
Ireland		X	0.601 (-0.10)	0.599 (-0.10)	0.377 (0.17)	**<0.001** (0.65)
Germany			X	1.000 (0.00)	0.223 (0.21)	**<0.001** (0.59)
Spain				X	0.190 (0.22)	**<0.001** (0.64)
Italy					X	*0.054* (0.35)
Israel						X

Note: The p-values were evaluated according to three-valued logic: font style is bold—seems to be positive; font size is ordinal—seems to be negative; and font style is italic—judgment is suspended.

It is worth mentioning that projects certified under previous versions of LEED-EB v3 and LEED-EB v4 measured only water and energy savings, and the overall LEED achievements were close to the low gold certification of 62-65 [51]. Over the years, such low achievements have been criticized as "point hunting" that neglects the true sustainability of the building [18]. In this study, four of the six countries assessed, Italy, Spain, Germany, and Ireland, achieved total LEED points from LEED-EB v4.1 gold-certified office projects that were well above the low gold certification (60 points). It can be assumed that this is due to the new approach taken in LEED-EB v4.1 to measure the performance of all the main indicators, transportation (LT), water (WE), energy (EA), waste (MRs), and indoor environmental quality (EQ). It can therefore be assumed that the current performance of all five streams (LT, WE, EA, MR, and EQ) reflects the real situation in the field of building sustainability.

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 15 July 2025 doi:10.20944/preprints202507.1228.v1

5. Conclusions

- For the transportation performance prerequisite, Sweden and Germany showed the highest scores and Italy showed the lowest, with Ireland, Spain, and Israel in between;
- For the water performance prerequisite, Germany showed the highest score and Italy showed the worst, with Sweden, Ireland, Spain, and Israel in between;
- For the energy performance prerequisite, Germany showed the highest score and Ireland and Israel showed the lowest, with Spain, Italy, and Sweden in between;
- For the waste performance prerequisite, Spain and Italy showed the highest scores and Germany and Israel showed the lowest, with Sweden and Ireland in between;
- For the indoor environmental quality performance prerequisite, Israel showed the highest score, and Germany and Sweden showed the lowest, with Ireland, Spain, and Italy in between;
- For overall LEED performance, Germany, Ireland, Spain, and Italy showed the highest scores, and Sweden and Israel showed the lowest.

6. Limitations

The current study had at least two limitations: (1) other LEED v4.1 rating systems need to be analyzed to obtain more complete information on current green building strategies, and (2) based on the knowledge of LEED professionals, an effect size level that would truly indicate "substantive significance" between countries should be adopted.

7. Future Research

Recently, three studies offered perspectives for future research: (1) used an expert team to estimate the efficiency of LEED-certified buildings [52] and (2) used structural equation modeling, and (3) used random forest regression and post-occupant satisfaction scores to estimate the occupant satisfaction in LEED-certified buildings [53,54]. Thus, using the methodologies described in the three studies mentioned above may help in better evaluating LEED-certified projects and shedding light on the development of future versions of LEED rating systems.

Appendix A

Table A1. Distribution of LEED-EB v4.1 gold-certified office projects among cities in six countries: Sweden, Ireland, Germany, Spain, Italy, and Israel.

Country	Cities (numbers)
Sweden (n = 36)	Gothenburg (10), Stockholm (8), Uppsala (4), Jonkoping (3), Danderyd (2), Malmo (2), Linkoping (1), Helsingborg (1), Vaxjo (1), Solna (1), Vasteras (1), Boras (1), Vastra Frolunda (1)
Ireland (n = 15)	Dublin (15)
Germany (n = 24)	Berlin (12), Hamburg (6), Munich (1), Dortmund (1), Kiel (1), Essen (1), Kassel (1), Wolfsburg (1)
Spain (n = 23)	Barcelona (10), Madrid (10), Alcobendas (1), Malaga (1), Valencia (1)
Italy (n = 24)	Milano (19), Roma (3), Biella (1), Torino (1),
Israel (n = 18)	Tel Aviv (8), Holon (4), Petach Tikva (2), Herzliya (2), Raanana (2)

Table A2. Distribution of fossil and renewable energy sources among cities in six countries: Sweden, Ireland, Germany, Spain, Italy, and Israel.

Country	Fossil sources				Renewable sources					
	Coal (%)	Oil (%)	Gas (%)	Total (%)	Solar (%)	Wind (%)	Hydropower (%)	Other renewables (%)	Nuclear (%)	Total (%)
Germany	16.00	35.16	23.87	*75.03*	5.02	11.65	1.61	4.98	0.57	23.83

Preprints.org (www.preprints.org) | NOT PEER-REVIEWED | Posted: 15 July 2025 doi:10.20944/preprints202507.1228.v1

Ireland	4.18	46.84	26.68	*77.70*	0.60	16.65	1.34	1.66	0.00	20.25
Israel	12.41	39.91	40.61	*92.93*	6.31	0.37	0.02	0.11	0.00	6.81
Italy	3.65	41.59	35.48	*80.72*	4.91	3.70	6.12	3.68	0.00	18.41
Spain	2.09	45.36	18.63	*66.08*	7.74	10.61	4.21	1.10	9.00	32.66
Sweden	3.03	21.67	1.20	*25.90*	1.35	14.92	28.71	6.06	20.21	71.25

References

1. Ade, R.; Rehm, M. The unwritten history of green building rating tools: A personal view from some of the 'founding fathers'. *Build. Res. Inf.* **2020**, *48*, 1–17.
2. Lei, M.; Cui, T. A Scientometric Analysis and Visualization of Global LEED Research. *Buildings* **2022**, *12*, 1099.
3. Madson, K.; Franz, B.; Leicht, R.; Nelson, J. Evaluating the Sustainability of New Construction Projects over Time by Examining the Evolution of the LEED Rating System. *Sustainability* **2022**, *14*, 15422.
4. Gluszak, M.; Malkowska, A.; Marona, B. Green Building Adoption on Office Markets in Europe: An Empirical Investigation into LEED Certification. *Energies* **2021**, *14*, 1971.
5. Li, X.; Feng, W.; Liu, X.; Yang, Y. A comparative analysis of green building rating systems in China and the United States. *Sustain. Cities Soc.* **2023**, *93*, 104520.
6. Pham, D.H.; Kim, B.; Lee, J.; Ahn, A.C.; Ahn, Y. A Comprehensive Analysis: Sustainable Trends and Awarded LEED 2009 Credits in Vietnam. *Sustainability* **2020**, *12*, 852.
7. Pham, D.H.; Kim, B.; Lee, J.; Ahn, Y. An Investigation of the Selection of LEED Version 4 Credits for Sustainable Building Projects. *Appl. Sci.* **2020**, *10*, 7081.
8. LEED-EB v4.1. Operation and maintenance. 2018. https://dcqpo543i2ro6.cloudfront.net/sites/default/files/file_downloads/LEED%20v4.1%20O%2BM%20Guide.pdf (accessed on 8 July 2025).
9. Laera, R.; de Pereda Fernández, L. Apolonio Morales 29, an intervention model for energy efficiency and building sustainability. *Bldg. and Mgt*. **2020**, *4(2)*, 4-10. http://dx.doi.org/10.20868/bma.2020.2.4690
10. El Sorady, D.A.; Rizk, S.M. LEED v4.1 operations & maintenance for existing buildings and compliance assessment: Bayt Al-Suhaymi, Historic Cairo. *Alex. Eng. J.* **2020**, *59*, 519–531.
11. Pushkar, S. Leadership in Energy and Environmental Design for LEED Version 4 (LEED-EB v4) Gold Certification Strategies for Existing Buildings in the United States: A Case Study. *Buildings* **2025**, *15*, 1080.
12. Hurlbert, S.H.; Lombardi, C.M. Final collapse of the Neyman-Pearson decision theoretic framework and rise of the neoFisherian. *Ann. Zool. Fenn.* **2009**, *46*, 311–349.
13. Hurlbert, S.H.; Lombardi, C.M. Lopsided reasoning on lopsided tests and multiple comparisons. *Aust. N. Z. J. Stat.* **2012**, *54*, 23–42.
14. Romano, J.; Corragio, J.; Skowronek, J. Appropriate statistics for ordinal level data: Should we really be using t-test and Cohen's d for evaluating group differences on the NSSE and other surveys? In Proceedings of the Annual Meeting of the Florida Association of Institutional Research, Cocoa Beach, FL, USA, 1–3 February 2006; Florida Association for Institutional Research: Cocoa Beach, FL, USA, 2006; pp. 1–33.
15. Volker, M.A. Reporting effect size estimates in school psychology research. *Psychol. Sch.* **2006**, *43*, 653–672.
16. Durlak, J.A. How to select, calculate, and interpret effect sizes. *J. Pediatr. Psychol.* **2009**, *34*, 917–928.
17. Wu, P.; Mao, C.; Wang, J.; Song, Y.Z.; Wang, X.Y. A decade review of the credits obtained by LEED v2.2 certified green building projects. *Build. Environ.* **2016**, *102*, 167–178.
18. Wu, P.; Song, Y.; Shou, W.; Chi, H.; Chong, H.Y.; Sutrisna, M. A comprehensive analysis of the credits obtained by LEED 2009 certified green buildings. Renew. *Sustain. Energy Rev.* **2017**, *68 Pt 1*, 370–379.
19. Sullivan, G.M.; Feinn, R. Using Effect Size—Or Why the P Value Is Not Enough. *J. Grad. Med. Educ.* **2012**, *4*, 279–282.
20. Chi, B.; Lu, W.S.; Ye, M.; Bao, Z.K.; Zhang, X.L. Construction waste minimization in green building: A comparative analysis of LEED-NC 2009 certified projects in the US and China. *J. Clean. Prod.* **2020**, *256*, 120749.
21. Pushkar, S. Evaluating LEED commercial interior (LEED-CI) projects under the LEED transition from v3 to v4: The differences between China and the US. *Heliyon* **2020**, *6*, *e04701*.

22. Pushkar, S. A Comparative Analysis of Gold Leadership in Energy and Environmental Design for New Construction 2009 Certified Projects in Finland, Sweden, Turkey, and Spain. *Appl. Sci*. **2018**, *8*, 1496.
23. Pushkar, S Assessing LEED Core and Shell (LEED–C-AND-S), v3 and v4 of gold office-type projects: The difference between Finland and Spain. *J. Green Build*. **2022**, *17(2)*, 109–123.
24. Pushkar, S. The Effect of Regional Priority Points on the Performance of LEED 2009 Certified Buildings in Turkey, Spain, and Italy. *Sustainability* **2018**, **10**, 3364.
25. Pushkar, S. LEED-EB Gold Projects for Office Spaces in Large Buildings Transitioning from Version 3 (v3) to 4 (v4): Similarities and Differences between Finland and Spain. *Appl. Sci*. **2020**, *10*, 8737.
26. Pushkar, S. Leadership in Energy and Environmental Design Commercial Interior Version 4 (LEED-CI v4) Gold-Certified Office Space Projects: A Pairwise Comparative Analysis between Three Mediterranean Countries. *Buildings* **2024**, *14*, 815.
27. Bergmann, R.; Ludbrook, J.; Spooren, W.P.J.M. Different outcomes of the Wilcoxon-Mann-Whitney test from different statistics packages. *Am. Stat*. **2000**, *54*, 72–77.
28. USGBC Projects Site. Available online: https://www.usgbc.org/projects (accessed on 8 July 2025).
29. GBIG Green Building Data. Available online: http://www.gbig.org (accessed on 8 July 2025).
30. Cliff, N. Dominance statistics: Ordinal analyses to answer ordinal questions. *Psychol. Bull*. **1993**, *114*, 494–509.
31. Fisher, R.A. Statistical Methods and Scientific Inference; Oliver & Boyd: Edinburgh, UK, 1956.
32. Beninger, P.G.; Boldina, I.; Katsanevakis, S. Strengthening statistical usage in marine ecology. *J. Exp. Mar. Biol. Ecol*. **2012**, *426–427*, 97–108.
33. Altman, D.G. Practical Statistics for Medical Research; Chapman and Hall: London, UK, 1991.
34. Gotelli, N.J.; Ellinson, A.M. A Primer of Ecological Statistics, 2nd ed.; Sinauer Associates: Sunderland, MA, USA, 2004; ISBN 9781605350646.
35. Kennedy-Shaffer, L. Before $p < 0.05$ to beyond $p < 0.05$: Using history to contextualize p-values and significance testing. *Am. Stat*. **2019**, *73*, 82–90.
36. Dolge, K.; Barisa, A.; Kirsanovs, V.; Blumberga, D. The status quo of the EU transport sector: Cross-country indicator-based comparison and policy evaluation. *Appl. Energy* **2023**, *334*, 120700.
37. Mandev, A.; Sprei, F. Country-level differences in the electrified kilometers of plug-in hybrid electric vehicles across Europe. Environ. *Res.: Infrastruct. Sustain*. **2024**, *4*, 041003.
38. Bendz, A.; Boholm, Å. Indispensable, yet Invisible: Drinking Water Management as a Local Political Issue in Swedish Municipalities. *Local Gov. Stud*. **2020**, *46*, 800–819.
39. Antwi, S.H.; Rolston, A.; Linnane, S.; Getty, D. Communicating Water Availability to Improve Awareness and Implementation of Water Conservation: A Study of the 2018 and 2020 Drought Events in the Republic of Ireland. *Sci. Total Environ*. **2022**, *807*, 150865.
40. Kasipiyawong, J.; Gayh, U.; Ghomi, M.R. The potential of rainwater harvesting and greywater recycling as an alternative domestic water resource in Bahnstadt-Heidelberg, Germany. *J. Water Sanit. Hyg. Dev*. **2024**, *14 (7)*, 486-496.
41. Palatnik, R.R.; Raviv, O.; Sirota, J.; Shechter, M. Water Scarcity and Food Security in the Mediterranean Region: The Role of Alternative Water Sources and Controlled-Environment Agriculture. *Water Resour. Econ*. **2025**, *49*, 100256.
42. Forni, L.; Fortuna, F.; Giarda, E.; Giovanardi, F.; Panarello, D. The 'Green buildings' directive: A quantification of its costs and benefits in two Italian regions. *J. Hous. Econ*. **2025**, *68*, 102057.
43. Schramm, L.; Terranova, C From NGEU to REPowerEU: policy steering and budgetary innovation in the EU. *J. Eur. Integr*. **2024**, *46*, 943–961.
44. Keliauskaite, U.; McWilliams, B.; Sgaravatti, G.; Tagliapietra, S. Financing European Union's buildings' decarbonisation strategy. *Energy Policy* **2025**, *198*, 114437.
45. Nguyen, T.; Van Nguyen, T.; Zhou, L.; Duong, Q.H.; Ieromonachou, P. Assessing the impact of EU policies on recycling supply chain: a system dynamics perspective on advancing packaging recycling capacity. *Ann Oper Res*. **2025**, 1-53. https://doi.org/10.1007/s10479-024-06438-y
46. Soares, S.; Serralha, F.; Paz, M.C.; Carriço, N.; Galatanu, S.-V. Unveiling the data: An analysis of plastic waste with emphasis on the countries of the E^{3}UDRES^2 alliance. *Heliyon* **2024**, *10*, e28375.

 doi:10.20944/preprints202507.1228.v1

47. Laureti, L.; Costantiello, A.; Anobile, F.; Leogrande, A.; Magazzino, C. Waste Management and Innovation: Insights from Europe. *Recycling* **2024**, *9*, 82.
48. Blázquez, T.; Suárez, R.; Ferrari, S.; Sendra, J.J. Improving Winter Thermal Comfort in Mediterranean Buildings Upgrading the Envelope: An Adaptive Assessment Based on a Real Survey. *Energy Build*. **2023**, *278*, 112615.
49. Pollex, J.; Lenschow, A. When talk meets actions – return to Commission leadership in EU environmental policy-making with the European Green Deal. *J. Eur. Public Policy*. **2024**, 1-26.
50. Scutaru, A.M.; Witterseh, T. Risk Mitigation for Indoor Air Quality using the Example of Construction Products–Efforts Towards a Harmonization of the Health-Related Evaluation in the EU. *Int. J. Hyg. Environ. Health* **2020**, *229*, 113588.
51. Pushkar, S. Impact of "Optimize Energy Performance" Credit Achievement on the Compensation Strategy of Leadership in Energy and Environmental Design for Existing Buildings Gold-Certified Office Space Projects in Madrid and Barcelona, Spain. *Buildings* **2023**, *13*, 2656.
52. Ismaeil, E.M.H. Sustainability-Based Value Engineering Management as an Integrated Approach to Construction Projects. *Buildings* **2024**, *14*, 903.
53. Goodarzi, M.; Naseri, S.; Tafazzoli, M. Beyond the Green Label: How LEED Certification Levels Shape Guest Satisfaction in USA Hotels. *Buildings* **2025**, *15*, 2108.
54. Goodarzi, M.; Berghorn, G.H. Pathways to Project Effectiveness in Sustainable Communities: Insights from a Residential Satisfaction Evaluation Model. *J. Archit. Eng*. **2025**, *31*, 04025014.