



Comparative Analysis of LEED Certification Trends in Western and Eastern Europe: An Overview of Adoption and Growth (2006–2024)

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Abstract

Buildings have a crucial role since they consume around 30% to 40% of the total energy resources. Green building certification is one of the solutions to limit the energy use in buildings. Sustainable certifications such as LEED (Leadership in Energy and Environmental Design) are essential for European carbon neutrality and advance sustainability practices. In addition, LEED is seen to indicate a consideration for sustainability aspects in construction and how healthy, efficient buildings are. The purpose of this research is to investigate the evolution of Leadership in Energy and Environmental Design (LEED) certification in both Western and Eastern Europe between 2006 and 2024. The study seeks to explore and understand the temporal LEED evolution patterns, certification level distributions, and sectoral variations. The findings from the analysis of 3587 LEED certified project indicate differences between Western Europe that leads in certifications with 81.1% of all LEED certifications in the region (2908 out of 3587 projects) due to advanced regulations and commitments, while Eastern Europe has only 18.9% (679 projects) but it demonstrated rapid growth, aligned with EU policies and economic evolution. The findings offer valuable thoughts using a regional comparability approach focusing on green LEED certified projects disparities and diagnose the problems that Disable the EU for being a sustainable continent.

Keywords: LEED certification, sustainability certification, green buildings, sustainability in Europe

1. Introduction

Sustainability certifications play a very important role in driving Europe to be a green carbon neutral continent by 2050 and reduce its Emissions with 55% by 2030 (Evaluating the Chances of Implementing the “Fit for 55” Green Transition Package in the V4 Countries, n.d).that is not only on meeting the EU targets, but it is about to change our living and building practices taking into consideration the climate on our daily life. Building sustainability may have a crucial role in this transition since they consume around 35% of the total energy resources (Aste et al., 2022). Green building certification is one of the solutions to limit the energy use in buildings, one of these certifications is the LEED certification (Leadership in Energy and Environmental Design), the world's most widely used green building rating system varying from building design and construction (BD+C), interior design and construction (ID+C), building operations and maintenance (O+M), neighborhood development (ND), homes and cities (U.S. Green

Building Council, n.d.). LEED certification provides a framework for healthy, highly efficient, and cost saving green buildings, which offer environmental, social, and governance benefits (Gomes et al., 2024).

The certification offers a wide range of certifications, Platinum, Gold, and Silver, making it accessible for all building types (Leite Ribeiro et al., 2025), from offices to residential complexes, it provides a frame for healthy, efficient, and cost-saving green buildings (U.S. Green Building Council, n.d.), and it is a globally recognized symbol of sustainability achievement and leadership.

Research Objectives:

- Examine how LEED projects have grown and spread in Western and Eastern Europe between 2006 and 2024.
- Compare the levels of certification and identify which sectors are driving or resisting adoption in each region.
- Investigate the relationship between economic growth (GDP) and the adoption of LEED certifications in both regions.

2. Literature Review

LEED and other environmental certification systems, such as BREEAM, DGNB, and HQE are represented differently across Europe. Western Europe shows strong adoption, and Eastern Europe is still late in the adoption, and it is concentrated in a few countries, notably Poland, which stands as the most advanced Eastern European adopter (Gluszak et al., 2021; Kulczyk-Dynowska & Nowicka, 2024). This shows a regional difference in green building adoption and reflects the market's innovativeness and institutional capacity (Piętocha, 2024).

The sustainability certifications can ensure approximately 10% higher property prices and 12% greater operating income in France, Germany, Italy, and Spain. This value is higher for Platinum and Gold certified properties (Ghosh & Petrova, 2024), This indicates that environmental performance is adding value financially. Hungary, as part of the Eastern group, is driven by environmental awareness, energy efficiency concerns, and corporate social responsibility. The adoption of green certifications in Budapest is concentrated only on IT, governmental, and banking & finance sectors. (Barbara Eszter Huszár, 2022).

LEED certification is considered a sign of sustainable projects worldwide. Europe is a perfect case to study the adoption and growth of LEED projects based on its diverse Western and Eastern economies and regulations. The characterization of Western Europe, with its mature economies and strict environmental policies (Mihai et al., 2023), contrasts partially with Eastern Europe, which is still transitioning toward sustainable development practices and growing its economies. (Green Economy Transition in Eastern Europe, the Caucasus and Central Asia, 2022)

LEED certification system operates within Europe alongside other international and regional certification systems, including BREEAM, DGNB, and HQE. BREEAM and LEED dominate the European certification market, with BREEAM holding 81% of the Polish market alone, followed by LEED with 15.7% and DGNB with 1.1% (Kulczyk-Dynowska & Nowicka, 2024). DGNB, which is supported by the balance of environmental, economic, and social indicators, is more diffused in the German speaking regions (Fatkullina et al., 2025; Wiik et al., 2023), where HQE is largely concentrated in France, where 90% of HQE certifications are issued (*Green Building Rating Systems and the New Framework Level(s): A Critical Review of Sustainability Certification within Europe*, n.d.; Maduta et al., 2023). The comparison of these certification systems confirms that LEED and BREEAM are more closely aligned with the

environmental performance indicators, while DGNB and HQE focus more on the details of the user comfort and environmental management categories (Jaberi & Poirier, 2024; Rodrigues et al., 2023).

Studies discussed how market actors choose between LEED, BREEAM, DGNB, and HQE depending on sectoral priorities and national policies. BREEAM is generally preferred for industrial, commercial, and large retail buildings due to its lifecycle oriented criteria (Feijão et al., 2024; *Full Article: Sustainable Building Rating Systems: A Critical Review for Achieving a Common Consensus*, n.d.). While DGNB is mostly used in retail and mixed use buildings and that's due to its balance of social and economic evaluation criteria (Rodrigues et al., 2023). LEED has a strong presence in the office, hotel, and education sectors (Pushkar, 2025), HQE is dominant in the residential sector in France, which reflects strong national alignment and the use of the local certification systems (Maduta et al., 2023).

3. Methodology

3.1 Data Acquisition and Filtering

This research utilizes a dataset of over 200,000 LEED-certified projects worldwide, which was sourced from a repository and manually downloaded from the official website of the US Green Building Council in December 2024. The raw dataset contained all registered and certified LEED projects worldwide, including information on project ID, country, city, certification level, certification date, sector, and owner type. The study focuses on the comparison of 16 countries and splits them into two groups: the Western European group, including Austria, Germany, the Netherlands, Belgium, France, Spain, Italy, and Portugal. The Eastern group, including Poland, the Czech Republic, Slovakia, Slovenia, Croatia, Hungary, Romania, and Bulgaria. This grouping wasn't only based on geographical locations and data availability, but also on the socio-economic differences. We then applied the following filters: removal of projects marked as confidential, removal of duplicate entries based on the unique USGBC project ID, exclusion of projects with missing country or certification year, exclusion of non-certified projects, and restriction of the period to certifications between 2006 and 2024. After filtering, the final analytical dataset contained 3,587 certified projects within the two groups.

3.2 Data Processing

To ensure methodological transparency, all data cleaning and aggregation steps were conducted using Microsoft Excel and partially in Python using a simple, reproducible workflow: import of the raw data, application of the filters described above, assignment of each project to a country and regional group, and aggregation of projects to the country, year, and levels. These steps can be repeated from the original USGBC data to reproduce the country, year LEED counts used in the analysis. The analysis was based on the certification levels (Platinum, Gold, Silver), where we categorize and quantify each level to calculate the regional ratios, such as 4:1 West: East certifications intensity ratio that was calculated based on the division of Western group certifications on the Eastern one which shows in this case that Western group is 4 times bigger in terms of number of certifications, to quantify the disparities described in this article ($R_{west/east} = N_{west}/N_{east}$). categories (community and development organizations, corporate and private sector, educational institutions, government entities, investors, non-profit organizations, other) were examined to show the diversity indices (e.g., 0.63 for the West vs. 0.46 for the East) reflecting the institutional differences across regions and the projects types (government/public order, healthcare, industrial/warehouse, military, office/commercial, other/confidential, public/community spaces, residential, retail, transportation) to identify the sector specific trends as the dominance of office/commercial projects (46.5% in the West and 71.4% in the East) and disparities in specialized sectors like

healthcare (26:0 West-East ratio). Additionally, spatial density analysis was incorporated, calculating metrics like LEED projects per km² of land C ($D_{LEED} = \text{Number of LEED} / \text{Area of the country in km}^2$) (e.g., Italy at 2.83×10^{-3} LEED/km²) and LEED per GDP using the GDP of the countries for 2023 (International Monetary Fund), ($E_{LEED} = \text{Number of LEED} / \text{billions of GDP}$), which required geospatial mapping tools to account for territorial sizes, regional variations and the GDP of the countries.

The analyzed data contains confidential records that were excluded from the analysis, and this is to ensure data privacy and implement the filtering to remove sensitive information. The time frame of the analyzed data was from 2006 to 2024. This includes the temporal trends such as the exponential growth rates (e.g., 34.8% annual growth in the West) and the turning points (e.g., 2010, 2013-2014), compound annual growth rate calculations to track the changes over time ($CAGR = (N_t/N_0)^{1/t} - 1$), where N_0 is the initial value of LEED projects, and N_t is the final value, and t stands for the time period. The methodology included the analysis of the data with GDP metrics (LEED/ billion US dollars of the GDP) using accurate official data (International Monetary Fund; Eurostat).

3.3 Policy Index Calculation

The creation of the policy index is to quantify the differences between countries in the implementation of the regulations related to green construction and sustainable certifications. It is based on three evaluation criteria. The first one is the degree of the implementation of the EU energy performance of building directive (EPBD) requirements, the second is the implementation of the national building energy codes, and the third is the presence of a national sustainability program that supports sustainable certification. Each criterion was scored 0 to 2 according to the degree of adoption and implementation. The final score of each country was calculated as the sum of the three sub scores.

3.4 Market Maturity Index Calculation

The market maturity index was calculated based on (A), the early adoption of each country, defined as $((2024 - \text{First certified project year}) - 12) / 6$, the formula was chosen on a way for the results to range between 0 to 1, the second parameter (I) is LEED per capita and the third parameter (D) is the institutional diversity, calculated based on Shannon diversity index. These parameters were weighted according to their relevance by giving 40% to early adoption, 20% to LEED per capita, and 40% to institutional diversity. The index was calculated based on this formula:

$$MMI_i = 0.4A_i + 0.2I_i + 0.4D_i,$$

3.5 Statistical Validation

3.5.1 Diversity Index (Shannon Index)

The diversity index was calculated based on Shannon-Wiener Index as follows:

$$H' = - \sum_{i=1}^n p_i \ln(p_i)$$

$$\text{Diversity index}(H' \text{ norm}) = \frac{H'}{\ln(n)}$$

n = number of institutional categories

$$p_i = \frac{x_i}{\sum_{i=1}^n x_j}$$

x_j = number of certified projects in category i

$\sum_{i=1}^n x_j$ = total certified projects across all categories

\ln = natural logarithm

The diversity index (H'_{norm}) ranges from 0 to 1, where higher values indicate greater institutional diversity and lower values show concentration within a few categories.

3.5.2 Uncertainty Reporting (CIs)

- **Regional Distribution of LEED Projects**

We computed 95% confidence intervals for the portion of projects located in the Western and Eastern groups in order to quantify the uncertainty in the regional distribution of LEED projects. Let $p = k/N$ denote the share of LEED projects in a region, where k is the regional count and N the total. The standard error was calculated as $SE = \sqrt{p(1-p)/N}$, and the 95% confidence interval was obtained as $p \pm 1.96 SE$. This proportion method provides a robust measure of uncertainty for comparing regional LEED adoption levels.

- **CI For Shannon Diversity Index**

The Shannon diversity index and its normalized form were accompanied by 95% confidence intervals derived from a non-parametric bootstrap procedure (10,000 resamples). For each bootstrap draw, the institutional composition was resampled with replacement, and the diversity metrics were recalculated. The confidence bounds were obtained from the 2.5th and 97.5th percentiles of the resulting empirical distribution. This approach captures sampling uncertainty in the relative proportions of institutional categories and provides statistically robust intervals for comparing Western and Eastern European markets.

- **CI For LEED Counts OR LEED Per Capita (Poisson CI)**

Because LEED projects are count data (number of projects per region), we approximated their uncertainty using a Poisson model. Let k denote the observed number of LEED projects in a given region. Under a Poisson assumption, the 95% confidence interval for k is calculated as:

For regional LEED intensity per capita, we first computed the rate

$$CI_{95\%}(k) = \left[k \exp\left(-\frac{1.96}{\sqrt{k}}\right), k \exp\left(\frac{1.96}{\sqrt{k}}\right) \right]$$

$$r = \frac{k}{Pop}$$

where Pop is the total population of the region, and then obtained the corresponding confidence interval by dividing the Poisson bounds by Pop :

For interpretability, we report rates as LEED projects per million inhabitants.

$$CI_{95\%}(r) = \left[\frac{CI_{95\%}^{\text{low}}(k)}{Pop}, \frac{CI_{95\%}^{\text{high}}(k)}{Pop} \right]$$

3.5.3 Regression Test

- **Regressions Linking LEED Counts To GDP**

To evaluate the relationship between economic capacity and LEED adoption, we estimated a log log linear regression at the country level. The dependent variable was the natural logarithm of the number of LEED projects $\ln(LEED_i + 1)$, and the predictor was the natural logarithm of national GDP (billion USD) as follows:

$$\ln(LEED_i + 1) = \alpha + \beta \ln(GDP_i) + \varepsilon_i$$

which provides an elasticity interpretation: a 1% increase in GDP is associated with a $\beta\%$ change in LEED adoption.

- **Regressions Linking LEED Counts to Market Maturity Index**

To examine whether market maturity is associated with LEED adoption, we estimated a linear regression with the natural logarithm of LEED projects as the dependent variable $\ln(LEED_i + 1)$ and the market maturity index as the independent variable, as follows:

$$\ln(LEED_i + 1) = \alpha + \beta \cdot MMI_i + \varepsilon_i$$

the index was previously calculated using indicators of time in the market, LEED intensity per capita, and institutional diversity.

3.5.4 Robustness Check

- **Regional Grouping**

To verify that the regional differences in LEED adoption are not based on how Europe is divided, we conducted a robustness check using the standard EU15–EU13 classification as an alternative grouping scheme. The EU 15 are the EU member states that were in the European Union before 2004, where the EU 13 are the EU member states that joined the European Union after 2004, we estimated a regression as follows:

$$\ln(LEED_i + 1) = \alpha + \beta \cdot EU15_i + \varepsilon_i$$

- **Per Capita Normalization**

To check whether the relationship between economic size and LEED adoption is sensitive to population differences, we conducted a robustness test using LEED projects expressed on a per-capita basis. For each country, we calculated

$$LEEDpc_i = \frac{LEED_i}{Pop_i} \times 10^6$$

$$\ln(LEEDpc_i + 1) = \alpha + \beta \ln(GDP_i) + \varepsilon_i$$

representing LEED projects per million inhabitants. The robustness regression was estimated based on:

4. Results and Discussion

4.1 Statistical Validation

4.1.1 Uncertainty Reporting (CIs)

- Regional Distribution of LEED Projects

Western group holds 81.1% of all LEED certified projects with a (CI95%: 79.8–82.4%), while the Eastern group holds only 18.9% (CI95%: 17.6–20.2%) as it's shown in Figure 1, confirming a strong and statistically robust regional imbalance in market adoption.

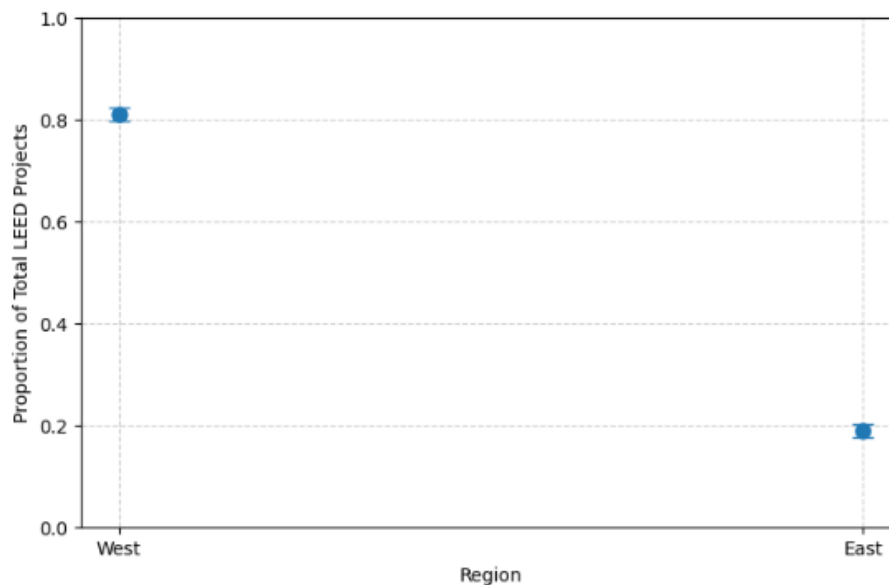


Figure 1: Uncertainty reporting for regional LEED projects distribution

- CI For Shannon Diversity Index

Institutional diversity is higher in the Western than in the Eastern group, as Figure 2 describes. For Western, the Shannon diversity index is $H' = 1.23$ (CI95%: 1.20–1.26), corresponding to a normalized value of 0.63 (CI95%: 0.62–0.65). In contrast, the Eastern group shows a lower institutional diversity, with $H' = 0.89$ (CI95%: 0.81–0.95) and a normalized value of 0.46 (CI95%: 0.42–0.49). This indicates a statistical difference in institutional diversity, supporting the interpretation that the Western LEED markets are not only larger but also diverse than Eastern ones.

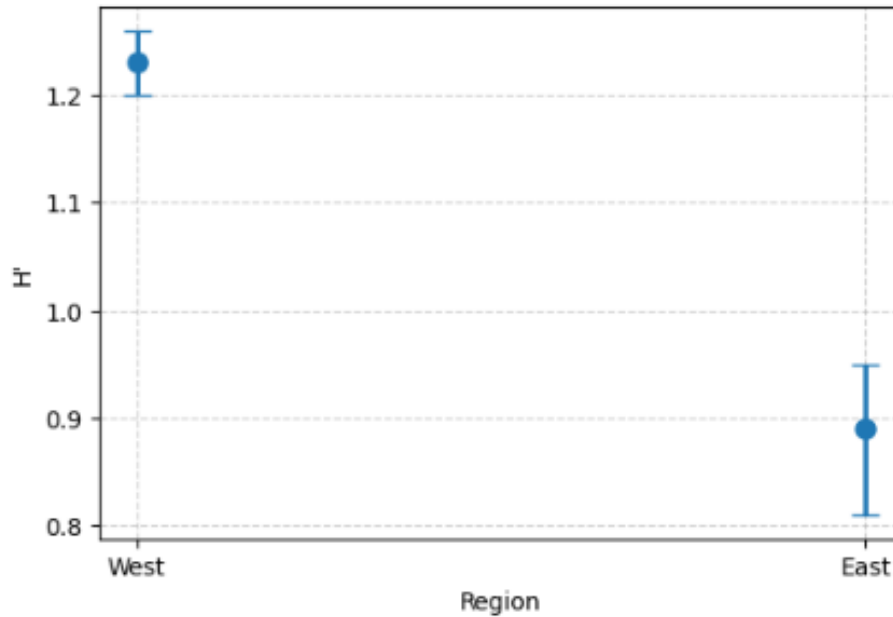


Figure 2: Uncertainty reporting for the diversity index

- CI For LEED Counts and LEED Per Capita (Poisson CI)

Western group records 2,908 LEED projects (95% Poisson CI: 2,804–3,016), corresponding to 9.45 LEED projects per million inhabitants (CI95%: 9.11–9.80). Eastern group records 679 projects (CI95%: 630–732), and 7.22 LEED projects per million inhabitants (CI95%: 6.69–7.78) as described in the analysis in Figure 3. This confirms that the Western group maintains a systematically higher level of adoption, even after accounting for population differences.

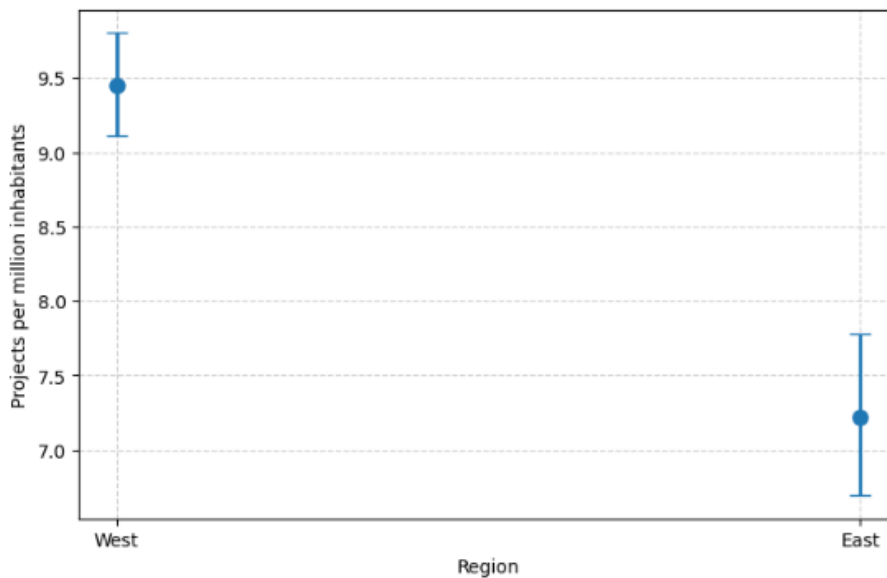


Figure 3: Uncertainty reporting for LEED per capita

4.1.2 Regression Test

- Regressions Linking LEED Projects To GDP

Figure 4 shows that the GDP has a strong statistical association with LEED adoption. The regression has a positive coefficient ($\beta = 1.113$, $p = 0.0001$), indicating that countries with

higher GDP tend to certify more LEED projects. The model has 67% of the cross-country variation in the adoption ($R^2 = 0.670$). This demonstrates that the national economic size is a major determinant of green building certification activity across Europe.

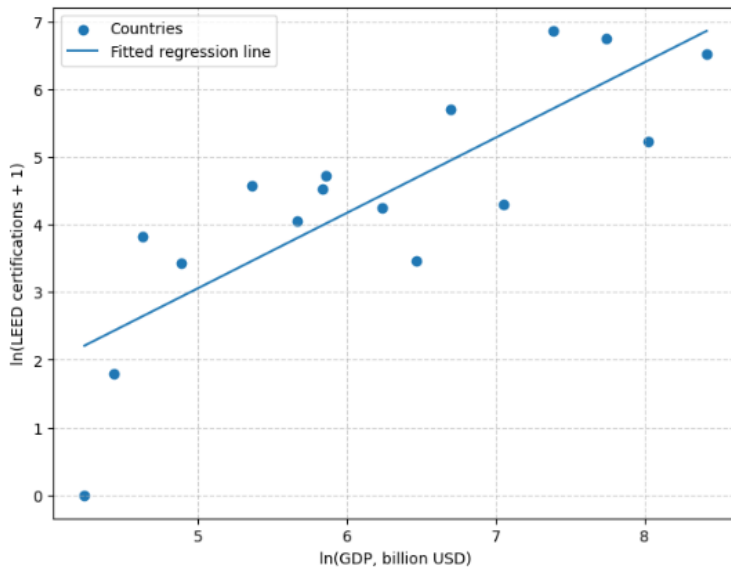


Figure 4: Regression test linking LEED projects to GDP

- Regressions Linking LEED Projects To the Market Maturity Index

The regression test in Figure 5 shows an association between the market maturity index and LEED adoption. The regression has a positive coefficient ($\beta = 6.708$, $p = 0.00017$), which indicates that countries with higher maturity scores have greater LEED adoption activity. The model gives a 67.5% as a cross-country variation ($R^2 = 0.675$), which confirms that the maturity evaluation parameters, such as earlier adoption, higher LEED per capita, and institutional diversity, are major parameters that substantially align with the higher LEED adoption.

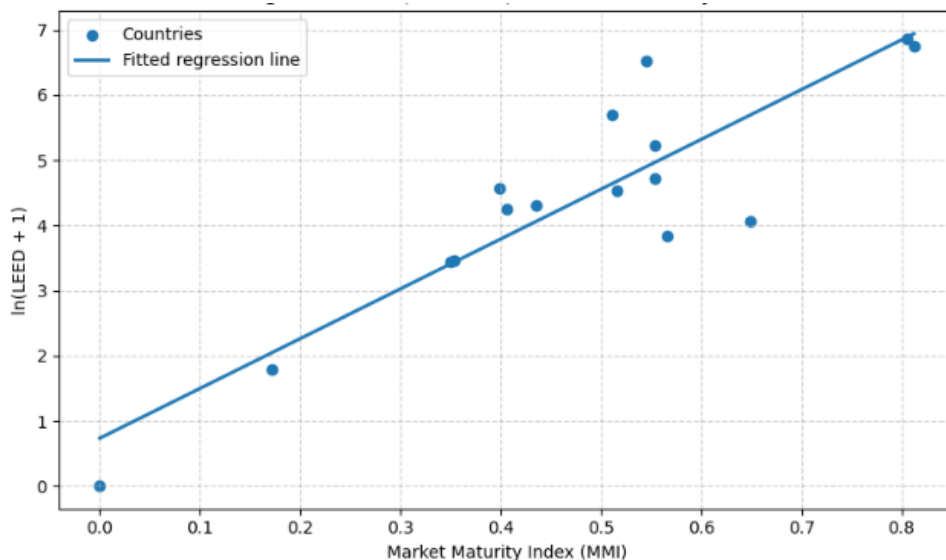


Figure 5: Regression test linking LEED projects to Market maturity index

4.1.3 Robustness Check

- Regional Grouping

Figure 6 represents the robustness check using the EU15, EU13 grouping as an alternative check, the estimated coefficient for the EU15 is $\beta = 1.096$, which indicates higher LEED adoption among the older Western group. The effect is not statistically significant ($p = 0.129$) and explains less variation ($R^2 = 0.168$). The regional differences do not depend on the initial grouping, and that was supported by this check.

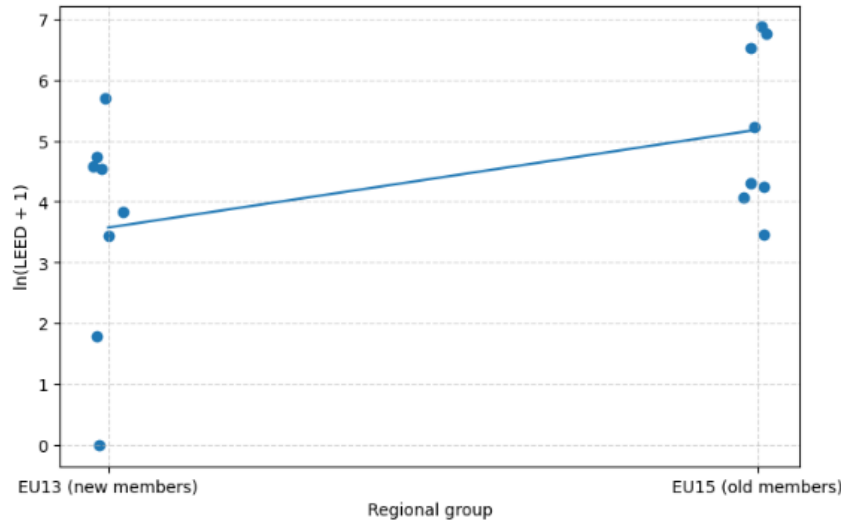


Figure 6: Robustness regression on alternative grouping

- Per Capita Normalization

The robustness check in Figure 7 gives a small, positive coefficient ($\beta = 0.140$, $p = 0.267$), with limited power ($R^2 = 0.094$). This indicates that GDP positively aligns with the total count of LEED projects, but not strongly with the intensity of LEED projects per capita.

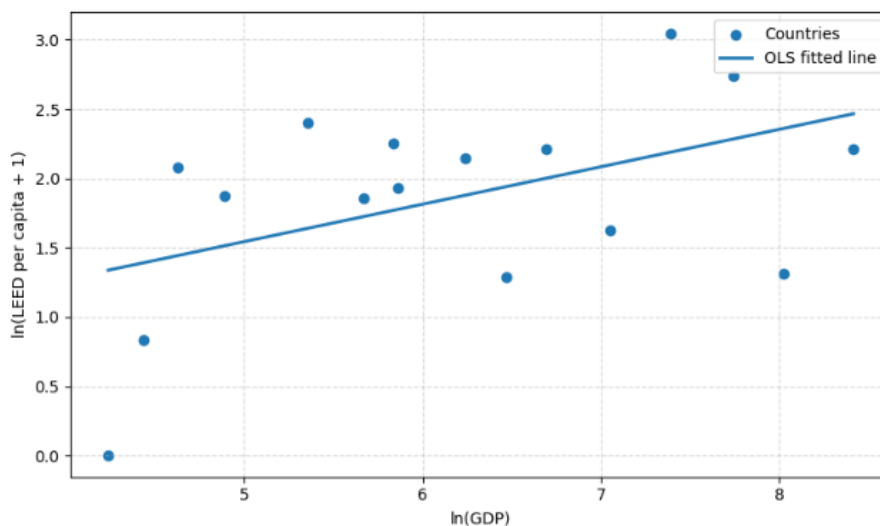


Figure 7: Robustness regression on LEED projects per capita normalization

4.2 Spatial Distribution of LEED Projects (2006–2024)

The Spatial distribution analysis of LEED projects in Figure 8 shows a significant geographical heterogeneity across the studied area with 3587 certified projects in total, with significant disparities between Western group with 2908 certified projects with 81.1% from the total of the certifications where the Eastern holds 679 certified projects with an 18.9% of the total

amount of the certified projects across Europe. The Western group, including Spain, Italy, Germany, France, Austria, Belgium, the Netherlands, and Portugal, demonstrates a higher certification density with an average certification per country of 363.5 certificates compared to the Eastern group that has an average of 84.9 certificates. The Mediterranean countries show a strong certification concentration, with Spain having 963 certificates and Italy 852, France 185, and Portugal 57, collectively accounting for 57.34% of total certifications. This North-South comparison of the Western Group itself is further proved by the significant differences between Mediterranean nations (514.25 certifications on average) and Northern European states, including the Netherlands, Germany, Belgium, and Austria, with a total of 851 certified projects, which didn't reach the number of certified Spanish projects.

The East-West dichotomy is characterized by a certification gap ratio of 4.28 certified projects in the West over only one in the East (4.28:1), the Eastern group displaying a significantly lower certification adoption rate despite their market sizes example of Poland, Romania, and the Czech Republic (International Monetary Fund, n.d.). Within the Eastern group, the adoption of LEED varies significantly, from Poland, the Eastern group leader, with relatively important implementation of 299 certified projects (Figure 8), which takes 44.03% of Eastern projects, to Slovenia's null adoption rate. The previous analysis shows the significant disparities between the Western and Eastern groups as well as the countries within the regions themselves. This spatial and cross region analysis may drive us to put forward the hypothesis of socio-economic determinants.

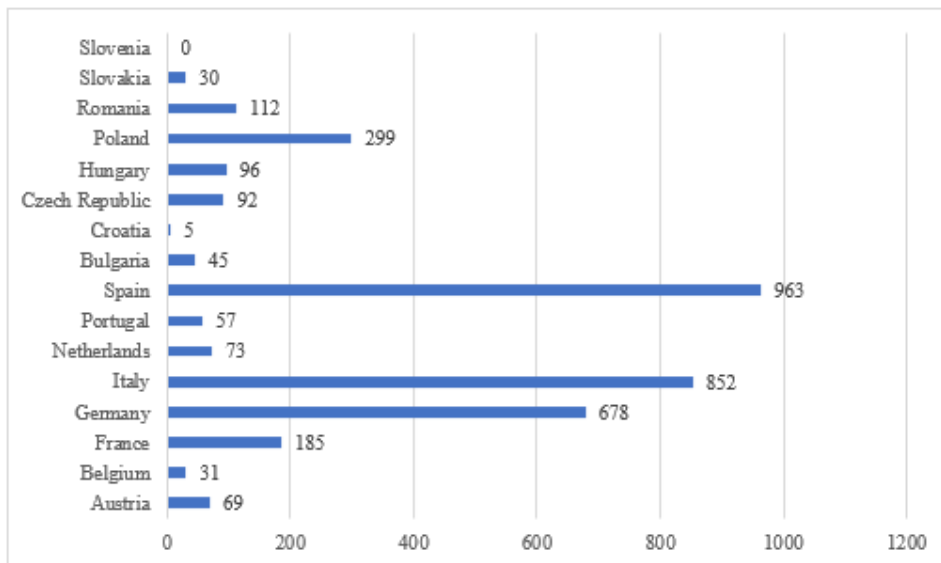


Figure 8: Number of LEED projects

Figure 9 shows the density analysis of LEED projects distribution, which holds significant regional variations across the area studied. Italy is leading the certification density with 2.83×10^{-3} LEED/km², followed by Germany and Spain with approximately 1.90×10^{-3} certifications/km². This analysis, which is based on the territorial size, demonstrates a West-East division; the Western group maintains higher certification densities than the Eastern, except for the Czech Republic and Hungary, which show intensity similar to Western standards. Italy is placed as a highly implemented country in LEED adoption by having the highest density, as well as being the 2nd ranking country in LEED certified projects from the study area, which suggests more implementation in the Italian territory. The differences between high-density nations and countries like Croatia that hold the minimal density or Slovenia with zero certifications confirm the geographical disparities in certification adoption

across Europe (Polster, 2021) and reflecting the differences in industrial development, economic growth, regulatory frameworks, or market maturity across regions. (Polster, 2021)

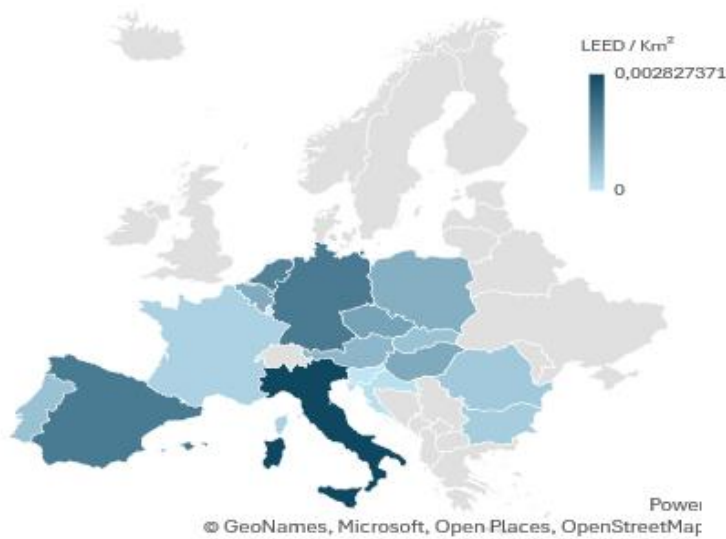


Figure 9: Index of the number of LEED projects per km² map

4.3 LEED Projects and GDP Analysis

The previous analysis has shown a dominance of the Western group over the Eastern, countries like Germany, Italy, and Spain have a significantly higher number of certified projects (Figure 8), associated with their industrial development, economic growth, and regulatory frameworks. (Gluszak et al., 2021), while Eastern countries such as Bulgaria, Slovenia, Slovakia, and Croatia still lag behind. The disparity is linked to the economic differences, as the Western group has higher GDPs that open the investment gate to the green building practices and sustainability initiatives (Gluszak et al., 2021) And that is widely clear when comparing the GDPs and the number of certificates. The Western group also benefits from more mature construction markets, stronger environmental policies, and greater awareness of sustainability (Green Business Certification Inc., 2021), which drives the demand for sustainability certifications. Poland, which holds 299 certifications, is making important progress as it integrates more with the Western group. (Plebankiewicz et al., 2019; Szymański et al., n.d.). This analysis shows each country's orientation in environmental policy and economic development, where economic capacity and policy play an important role in green building adoption.

The analysis of the rate of LEED projects per GDP as detailed in Figure 10, shows a very interesting outcome: Spain has the highest number of certifications compared to its GDP, with 0.59 certifications per billion dollars, highlighting the importance of sustainable urban development in Spain (Diaz-Sarachaga & Sánchez-Cañete, 2024). Hungary and Bulgaria are more sustainability-friendly compared to their economic size, respectively, with 0.452 and 0.439 certifications per billion dollars, and that is reflecting the significant efforts that were made in both countries despite the limited resources. (Soreg & Bermudez-Gonzalez, 2021; Tankovsky & Endrődi-Kovács, 2021). France and Belgium have low rates with 0.061 and 0.048 certifications per billion dollars, and that is reflecting the use of alternative green building systems like HQE in France, which is more widely adopted in the country. (Esteve & Brebbia, 2011; Gazzeh, 2010; Polli, 2020).

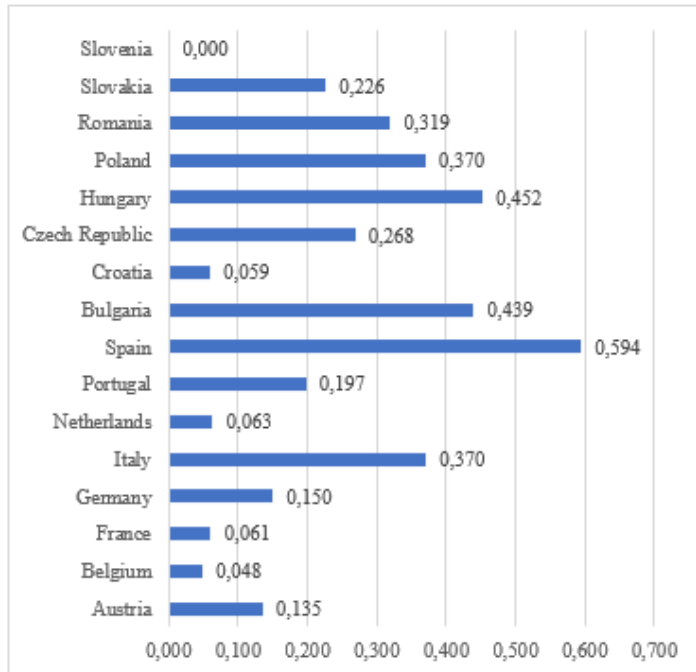


Figure 10: Index of the number of LEED projects per billion dollars of GDP

4.4 Temporal Trends in LEED Projects (2006–2024)

The Examination of the temporal data shows significant disparities in project distribution between Western and Eastern groups over an 18-year period. Western group shows a consistent domination of the certified projects increase, maintaining a mean representation of 80.00%. Figure 11 shows an exponential growth in Western projects from 2 in 2006 to 432 in 2024, representing a compound annual growth rate of 34.8 %, while Eastern projects exhibited a more moderate increase with an annual growth of 27.36%. There have been significant turning points occurred, in 2010 (first major scale-up), 2013-2014 (expansion beyond 100 Western certified projects), and 2021-2024 (peak activity exceeding 400 Western certified projects annually). The Western percentage of certified projects shows a remarkable stability, ranging from 67% to 100%, in recent years (2021-2024) it indicating a serious trend to Western dominance (85-88%). All this shows a huge difference between the Western group, which has an exponential LEED certified projects trend, while the Eastern group still needs to put more effort into sustainability.

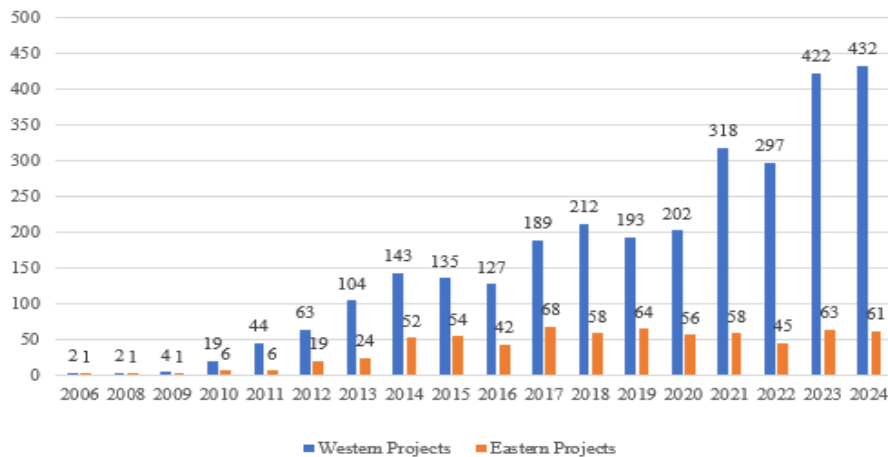


Figure 11: Temporal evolution of the number of LEED projects (2006-2024)

4.5 Project Levels Distribution

The analysis in Figure 12 of LEED projects tier shows an East-West disparity across European territories. The Western group (Spain, Italy, Germany, France, Austria, Belgium, the Netherlands, Portugal) collectively dominate with 1,872 Gold certifications which is 83.7%, 526 Platinum certifications which is 71.4%, and 340 Silver certifications which represents 81.9% of total certified projects, while Eastern European countries have 374 Gold (16.3%), 210 Platinum (28.6%), and 75 Silver certifications (18.1%). This regional disparity is particularly well shown in the highest achievement levels, where Spain and Italy alone (359 Platinum certifications) surpass the entire Eastern European region's Platinum count by 71%. The certification intensity ratio (West: East) shows a consistent ratio of approximately 4:1 across all tiers. The gap is clearer in gold certifications (5.1:1) and less in Platinum certifications (3.4:1). While Western group maintains relatively stable proportions across certification tiers (Gold: Platinum: Silver \approx 5:1.5:1), Eastern European territories show more variability in their distribution pattern (Gold: Platinum: Silver \approx 5:2.8:1), suggesting different certification strategies or capability levels between the regions.

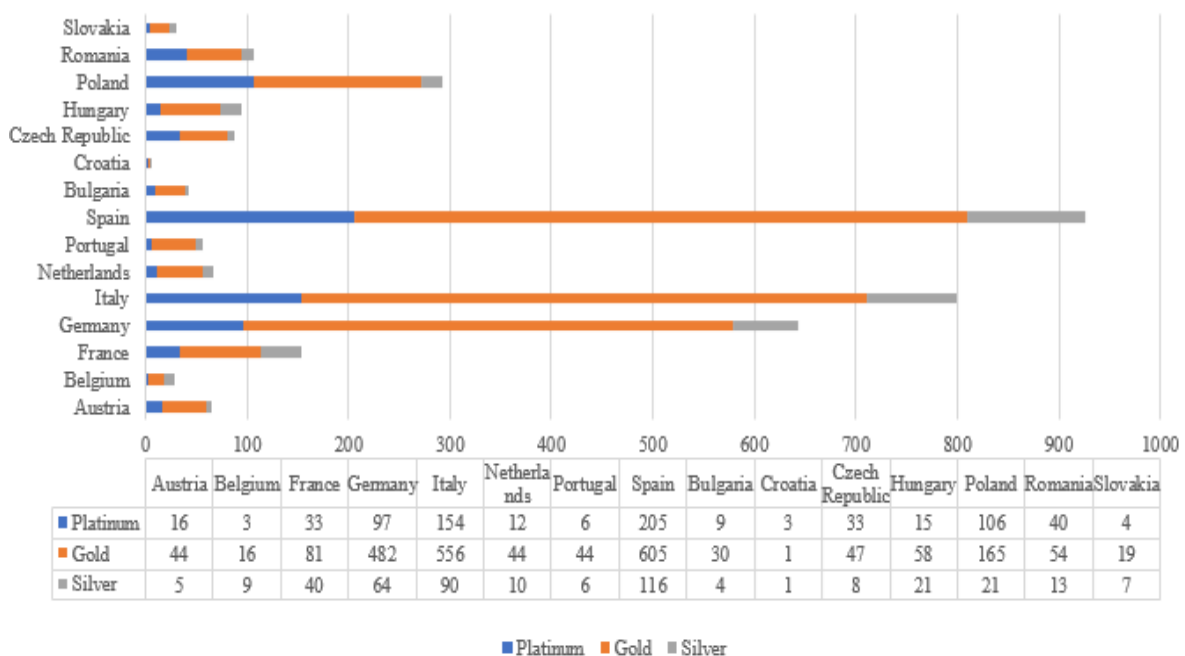


Figure 12: The distribution by level of LEED projects

4.6 Sectoral Analysis

4.6.1 By Project Category

The sectoral analysis of LEED projects distribution in Figures 13 and 14 shows disparities in the organizational participation between Western and Eastern groups. The corporate and private sector dominates certification adoption in both regions, representing 50.7% of Western projects (n=1,477) (Figure 13) and 65.9% of Eastern projects (n=448) (Figure 14), followed by investors as the second most active category (28.1% and 27.4% respectively). However, the regional disparities are well shown in the other sectors and are particularly evident in government entities (West: East ratio of 22.6:1) and Other categories (15:1), and that is linked to the institutional and structural differences between regions. The gap is well shown in the educational institutions and non-profit organizations as well, where Western group pass the Eastern by factors of 5:1 and 9.2:1, respectively, indicating the sustainability challenges across sectors in the regions (Lopatkova, 2021). This sectoral distribution shows not only quantitative

differences but also qualitative variations in certification adoption. The Western group demonstrates more diverse participation across the organizational categories, with a diversity index of 0.63 compared to the Eastern region's concentrated distribution, with a diversity index of 0.42, which is more concentrated on corporate and investment sectors.

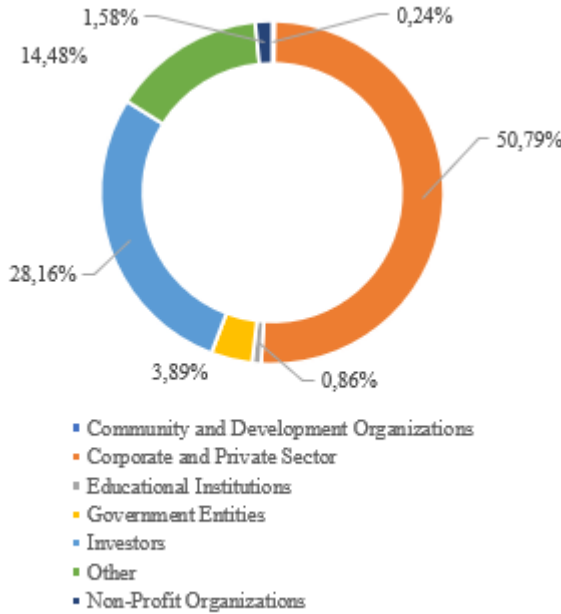


Figure 13: Distribution by category of LEED projects in the Western group

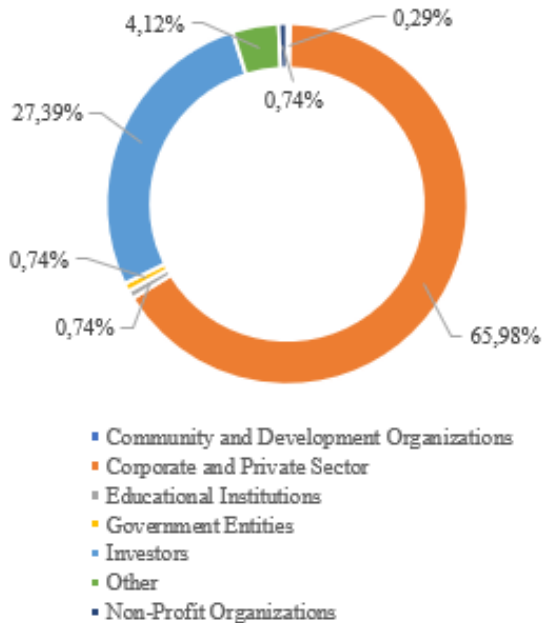


Figure 14: Distribution by category of LEED projects in the Eastern group

4.6.2 By Project Type

The Analysis of LEED projects by projects shows a difference in the distribution across the European regions. Office / commercial projects dominate in both Western and Eastern groups,

with 46.5% and 71.4% respectively. The Western group, as shown in Figure 15, demonstrates greater diversification across project types, with substantial representation in industrial/warehouse with 10.4%, retail with 12.9% and other/confidential categories with 21.6%. On the other hand, Figure 16 show a dense concentration in office/commercial and industrial/warehouse sectors, together with 79.9% of all Eastern certifications.

There are disparities in the specialized sectors, including healthcare (26:0 West: East ratio), education (8.4:1), and public/community spaces (6.3:1), and that is associated with the sector-specific expertise or market maturity between regions. (Cristobal-Campoamor & Parcerro, 2013). The categories distribution across the Western group with eleven categories compared to the Eastern to the maturity and the development of the market (Polster, 2021) Certain categories, such as military and transportation facilities, exist only in the Western group, which would open the gate for the Eastern as well, for more sustainability.

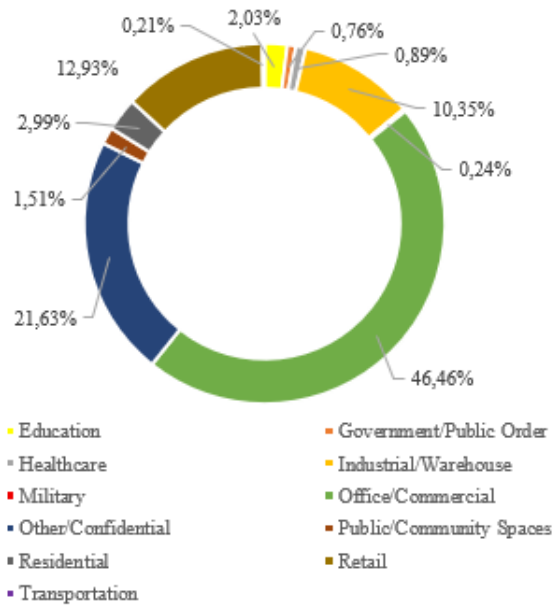


Figure 15: Distribution by project type of LEED projects in the Western group

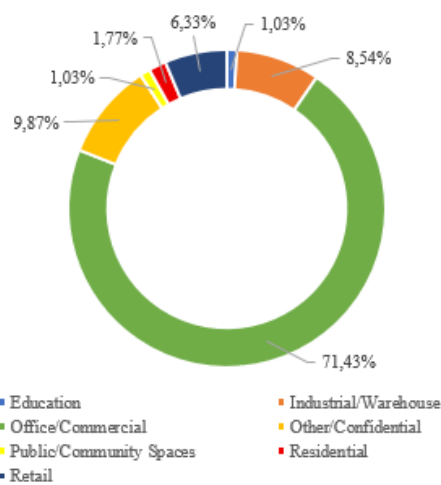


Figure 16: The distribution by project type of LEED projects in the Eastern group

4.7 Policy Index and Market Maturity

4.7.1 Market Maturity

Figure 17 shows a difference in the market maturity index values across countries. Italy (0.812), Spain (0.805), and Portugal (0.649) prove the highest maturity levels, and that's linked to their early adoption, strong certification activity, and diverse institutional adoption. Followed by Germany (0.545), France (0.554), and Bulgaria (0.566). In Eastern Europe, Croatia registers the lowest value (0.172), followed by Slovakia (0.350), Belgium (0.353), and Hungary (0.398), which indicates their late adoption and moderate institutional diversity. All this demonstrates that Western markets generally have more advanced and mature markets, while the Eastern markets remain to be developed.

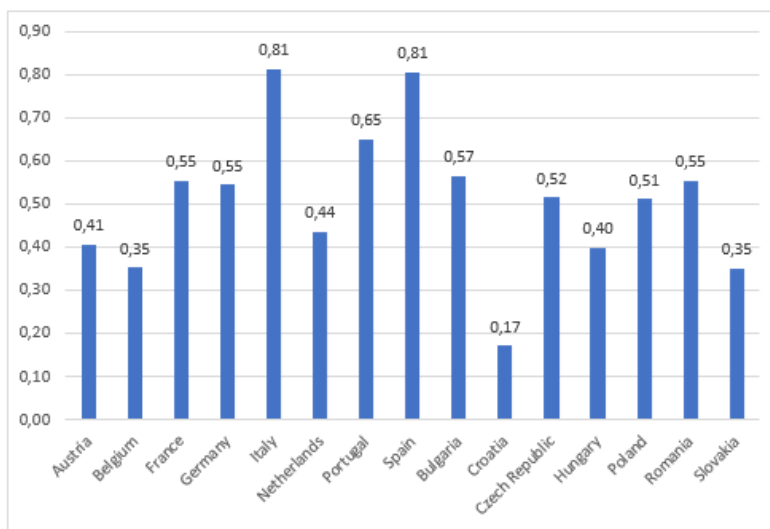


Figure 17: market maturity index

4.7.2 Policy Index

The Western group, including Austria, Belgium, France, Germany, the Netherlands, and Spain, achieves 6 points as in Figure 18, indicating a strong regulatory alignment, comprehensive EPBD implementation, and well-established national sustainability policies. Portugal and Italy follow with scores of 4, reflecting policy implementation. The Eastern group scores substantially lower, with Bulgaria, Hungary, and Romania each scoring 1, Slovakia and Croatia scoring 2, and Poland scoring 3, placing them well below the Western group.

The Western group shows a higher trend in LEED projects adoption, the reason is either by the European Union's regulatory strategies, such as the 2020 Climate and Energy Package and the 2030 Climate and Energy Framework. (Moga & Maghiar, 2020), or local policies such as the building energy act (Gebäudeenergiegesetz, GEG) (Bundesministerium für Wirtschaft und Klimaschutz, 2024) in Germany and RE2020 (Ministère de la Transition Écologique, 2020) in France, which together promote sustainable construction and zero energy buildings. The region has high mature markets and high rates of sustainable certifications adoption (LEED, BREEAM) (Maier et al., 2024). The integration of smart technologies and energy efficiency initiatives, including Smart Readiness Indicator (SRI), improves the sustainability in the region. (Chatzikonstantinidis, 2025).

On the other hand, the Eastern group faces less developed local policies and market structures and slow adoption of the EU directives, and that is causing less adoption of sustainability certifications, including LEED. (Moga & Maghiar, 2020). Hungary has Institutional capacity and governance obstacles that slow energy-transition implementation. (Szabo et al., 2021), where Romania and the Czech Republic have a knowledge gap on whole life carbon assessment

and weak incentives, which makes the adoption slow (*Whole Life Carbon Assessment of Buildings: The Process to Define Czech National Benchmarks*, n.d.).

European strategies and actions have not completely overcome the difficulties imposed by economic and infrastructure problems, which still require investment in research and development to stimulate the maturity of the market and the adoption of certifications. (Maier et al., 2024).

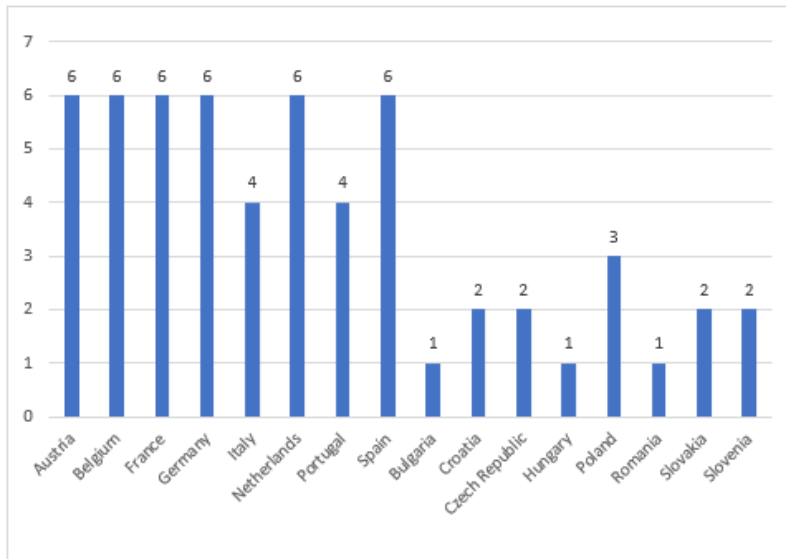


Figure 18: Policy index

4.8 Actionable Stakeholder Implications

4.8.1 Policymakers & Public Sector

The Western group has to put on more effort in minimum energy performance standards (MEPS) to maintain sustainable and enhance the energy performance in buildings, and encourage the adoption of sustainable certifications. (Eichholtz et al., 2024.; Fregonara & Rubino, 2021; McAllister & Nase, 2023) While the Eastern must remove governance and financial barriers, reorganization of homeowners and facilities managers into a united organization to facilitate decision making, and prioritizing the district heating decarbonization and municipal heat planning to realign with systems upgrade (Frilingou et al., 2024).

4.8.2 Investors

Investors in the West are increasingly relying on green certifications and energy performance to enhance the value of the asset. Green certified buildings have a significant premium price. (Copiello & Coletto, 2023; Ghosh & Petrova, 2024; Porumb et al., 2020) And are considered a sustainable investment. In the Eastern market, which is considered weaker, it is advised to focus on smaller projects and enhance the building's performance. (Copiello & Coletto, 2023).

4.8.3 Designers and Construction Companies

Whole life carbon WLC and certification standards are considered early in the design phase in the Western group to align with the regulations and the market demand. Research proves that the certified buildings are performing better compared to the non-certified buildings. (Fregonara & Rubino, 2021; Porumb et al., 2020; Wang et al., 2025). In the Eastern group, improving data quality, professional skills, and the reliability of Energy Performance Certificates (EPCs) is still needed in order to ensure the certification frameworks are accurate and feasible. (Fregonara & Rubino, 2021).

4.8.4 Building Owners and Communities

In the West, building owners are adopting certified and high-performing buildings to prevent asset devaluation. Research demonstrates that certified buildings have more consistent value in the market, which reflects investor confidence. (Espinoza-Zambrano et al., 2024; Fregonara & Rubino, 2021; Porumb et al., 2020). In the East, the efforts are focused on making renovations and certifications more accessible and feasible through financial aid and technical support. Strong policies and assistance are important to help communities, especially those struggling with energy costs, to be part of the shift to energy-efficient housing. (Fregonara & Rubino, 2021).

5. Conclusion

The analysis showed the adoption rates of Sustainability LEED projects in both Eastern and Western groups. Western with 81.1% of all LEED certified projects (2,908 out of 3,587) show more leadership aspects in sustainability, with high certification densities, with Italy leading with 2.83×10^{-3} LEED/km². The West dominance in LEED practices is mostly related to their economic development, as shown in the LEED per GDP analysis, which shows the lead of Spain with 0.59 certifications per billion dollars of GDP, and that is reflecting the importance of sustainability in urban development and construction practices in the case of Spain. Eastern Europe, with only 18.9% (679 projects) of the total still need to put on more efforts into sustainability to maintain both economic growth and sustainability and to catch up the exponential growth trends observed in the West (e.g., a 34.8% compound annual growth rate from 2006 to 2024) and address their internal issues such the lower GDP per certification index in Bulgaria and Hungary for example despite their progress.

The focus on smart technologies and early whole-life carbon, as well as the strong implementation of EU frameworks and the national policies that promote energy efficiency and certification, are the main reasons for the Western group to lead the sustainability in buildings. Eastern Europe is still struggling with institutional and financial obstacles that slow the adoption of sustainability standards. There is still a need for investment in governance, funding, and technical capacity to keep the market growing.

Western groups with strong implementation of EU frameworks and the national policies that promote energy efficiency and certifications are giving strong support for sustainable buildings in the region. Also, the focus on smart technologies and early whole-life carbon contributes positively to the performance of the buildings. On the contrary, Eastern Europe is still struggling with institutional and financial obstacles that slow the adoption of sustainability standards. There is still a need for investment in governance, funding, and technical capacity to keep the market growing.

To maintain both economic growth and sustainability, the Eastern group must prioritize the policies that drive their economies to be greener and more sustainable. They have to focus more on sectoral diversification, where the Western group should have more variety in project types and categories. The findings highlight the gaps between both Eastern and Western groups, which must disappear to lead the carbon neutrality project of the EU, and that could come true with the increase of cross-regional collaborations and investments in sectors and categories between the countries.

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