

Credit Success Rates of Certified Green Buildings in Turkey

Xhensila THOMOLLARI¹

Vedat TOĞAN²

ABSTRACT

The green building rating systems have been used as a tool to evaluate the environmental impact of buildings since 1990. In Turkey, Leadership in Energy and Environmental Design (LEED) is in the first place concerning the total number of certified green buildings and then followed by Building Research Establishment Environmental Assessment Method (BREEAM) and German Sustainable Building Council (DGNB). This paper aims to give general information concerning the 287 certified green buildings, and to investigate an updated situation of credit success rates of 127 LEED new construction certified green buildings in Turkey. The results show that the certified green buildings in Turkey have a lower average percentage of credit success rates in indoor environmental quality, energy efficiency, and material and resources categories compared to the other groups. Also, despite the increasing number of the certified projects mostly office buildings through the years, it is noticed an unequal geographical distribution of the examples.

Keywords: Credit success, LEED, Sustainable Development, Turkey.

1. INTRODUCTION

For the developing countries, construction industry, among the other industries, has been leading industry that contributes significantly to the economic development. However, though it contributes to the economy, this sector has negative impacts on environment. For example, the building stock is responsible for using 40% of all raw materials, 17% of freshwater withdrawals, consuming around 40% of total energy used, and generating 40% of the total solid waste [1-3]. Therefore, to reduce these adverse effects, designing and building sustainable or green projects are getting more important day by day. Since 1990, building sustainability level has been measured by international green building rating systems. It is estimated that around 600 green rating systems exist globally [4]. In 1990, Building Research

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1 Karadeniz Technical University, Department of Civil Engineering, Trabzon, Turkey-
xthomollari@gmail.com - <https://orcid.org/0000-0002-8158-3126>

2 Karadeniz Technical University, Department of Civil Engineering, Trabzon, Turkey - togan@ktu.edu.tr -
<https://orcid.org/0000-0001-8734-6300>

Establishment Environmental Assessment Method (BREEAM) was the first rating tool with the aim to assess the building’s performance through various criteria under several categories. After BREEAM, several international rating systems Leadership in Energy and Environmental Design (LEED), German Sustainable Building Council (DGNB), Comprehensive Assessment System for Built Environment Efficiency (CASBEE), High Quality Environmental (HQE) and national rating systems such as Green Globe in Canada, Green Star in Australia, BEAM in China and lately CEDBIK in Turkey etc., have been applied to evaluate the sustainability level of buildings. BREEAM-certified buildings have shown 3-30% less energy consumption than conventional structures [5], while LEED-certified ones consume 18-39% less energy than conventional ones [6, 7]. Some of the economic benefits are 1-25% occupant productivity increase, minimum 14% higher rate of return, 10% higher market value of the asset, and 5-10% higher rental rate [5, 7-9]. Therefore, the trend of designing and constructing green buildings started to spread worldwide.

All rating systems have continuously been upgrading and adopting the list of criteria to assess more accurately the sustainability aspects of buildings. For example, in 2013, LEED through the LEED v4 version made a lot of changes in the list of criteria and the attributed points for each category. Similarly, BREEAM made a significant update in 2014 and 2016 [4, 9, 10]. Fig.1 shows chronological development of the BREEAM and LEED systems’ versions and illustrates the percentage of credits of each assessment category in the respective version.

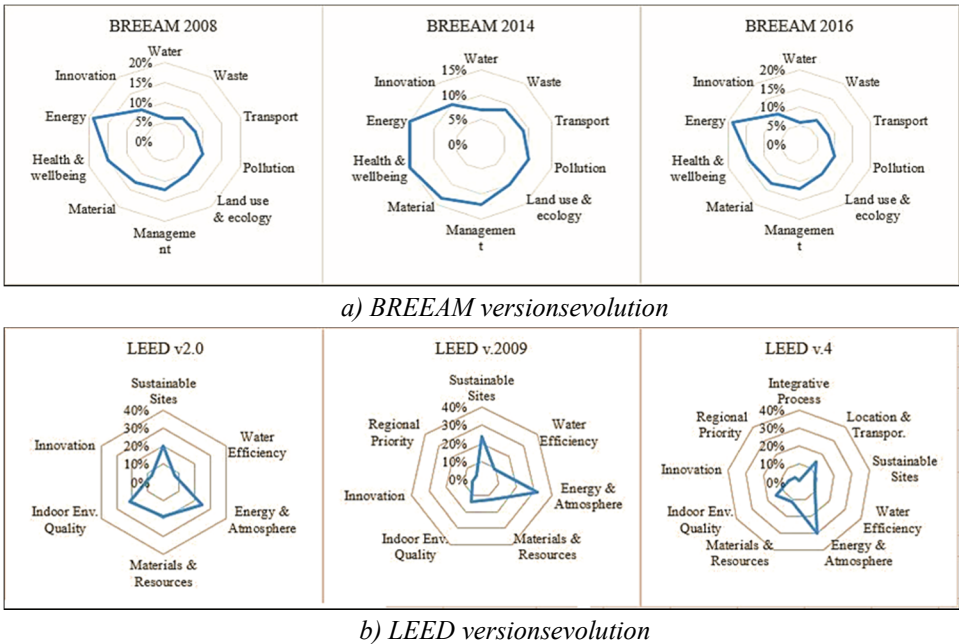


Figure 1 - Chronological development of BREEAM and LEED new construction scheme

The rating systems operating in Turkey are BREEAM, LEED, DGNB, and lately CEDBIK. There are 286 certified green buildings in Turkey, 242 of them are LEED, 43 of them are BREEAM, and one of them is DGNB certified, projects at the time of the study in October

2017. However, there was only one CEDBIK-certified project, since this national rating system was launched in the Turkish Market in 2016. The key features of these systems are introduced in Table 1. One main difference among these systems is the evaluation methodology. While BREEAM and DGNB use individual weightings for each assessment issue depending on the importance of the category, LEED and CEDBIK implement a simplified points system or scorecard. In 2015, Turkey was ranked in the 9th position regarding the total number of LEED-certified projects [11]. This ranking and the increased number of registered projects for certification under the LEED system (as seen in Fig. 5) indicate that interest in green construction practices in Turkey has been growing.

1.1. Literature Review

In the literature, there are many comparative studies related to different green building rating systems. These studies aimed to emphasize the differences between these rating systems by comparing them according to scheme typology, geographical distribution, indicators categories and attributed credits, standards used for establishing reference buildings during evaluation, etc. [4, 7, 12-17]. It can also be found several studies, in which the differences in the total obtained credits for a particular project evaluated according to various green rating systems, were pointed out [18, 19]. The different standards adopted in the rating systems used and the regional features of the state origins, where these rating systems were found, produced the variation on the results [18, 19]. There are limited studies in which the certified projects' allocation credits were analyzed. Ma and Cheng [20] examined 1000 projects in the United States certified by LEED-NC v2009. They used the percentage of average score method to explain the rate of credits achievement in individual subcategory criteria. Wu et al. [21] reviewed all the LEED v2.2 certified projects until its certification sunset date and concluded that the percentage of credit achievements in various categories varies in different countries. Moreover, Wu et al. [22] analyzed the credit allocation pattern of 3416 LEED v.2009 certified projects around the world. This study revealed that energy-related and material-related credits showed difficulty to achieve credits.

Wu et al. [23] investigated the credit achievement pattern of 4021 LEED v.2009 certified projects in the United States of America, China, Turkey, and Brazil. The results indicated that each country analyzed demonstrated different performance achievement in most rating categories including sustainable sites, water efficiency, energy and atmosphere, indoor environmental quality, and innovation in design. Also, Da Silva and Ruwanpura [24] compared the credit achievement of 42 LEED-certified projects in Canada with LEED-certified projects in the United States of America based on credit frequency indicators (CFIs). The study pointed out that factors such as climate conditions and regional location influence the credit achievement of the projects. Furthermore, there are several papers that were examined the credit achievements of Green Star certified projects. For instance, Xia et al. [25] analysed 388 certified building projects and Zuo et al. [26] examined 264 certified office projects with Green Star certificate located in Australia. The studies pointed out the easiest and most difficult categories to achieve credits during the certification process are based on the project types. Moreover, there is a lack of investigating LEED-certified projects in Turkey. Very few studies were carried out a partial analysis of particular samples of the certified projects in Turkey. Celik [27] evaluated 66 LEED-certified buildings in Turkey regarding their certification dates, the scores they have earned, their types and locations.

Bastanoglu[28] examined 52 Gold LEED new construction certified green buildings. Gokbayrak [29] assessed certified buildings under LEED new construction scheme in six different countries, among of which 102 certified projects in Turkey, and argued how the green building numbers, the projects’ certificate types and its evaluation criteria are correlated with the countries’ development levels. Also, Gunes [30] analysed 9 LEED and 6 BREEAM-certified projects, which have obtained a higher score at the time of preparing the study. On the other hand, Uğur and Leblebici [55] investigated in two green buildings certified as gold and platinum levels according to the LEED certification system in terms of construction and operating costs and property value. As implied from above, there is still a necessity for a full up-to-date investigation of the certified green buildings in Turkey.

Table 1 - Main features of BREEAM, LEED, DGNB and CEDBIK

	BREEAM	LEED	DGNB	CEDBIK
Country	UK	US	Germany	Turkey
Organizations	BRE	USGBC	DGNB	CEDBIK
No. of country implemented	77	160	20	1
Latest version	2016	2013	2017	2016
Categories	Management Health & Wellbeing Energy Transport Water Material Waste Land Use & Ecology pollution Innovation	Integrative Process Location and Transportation Sustainable Sites Water Efficiency Energy and Atmosphere Materials and Resources Indoor Environmental Quality Innovation Regional Priority	Environmental Economic Social-cultural and functional Technical Process Site	Integrative Process; Land use Water Efficiency Energy Health and Comfort Materials and Resources Life on Property Operation and Maintenance Innovation
Evaluation method	Pre-weighted categories	Additive credits	Pre-weighted categories	Additive credits
Certificate level	Pass >30 Good >45 Very good >55 Excellent >70 Outstanding >85	Certified >40 Silver >50 Gold >60 Platinum >80	Bronze >50% Silver >65% Gold >80%	Certified >45 Good >65 Very good >80 Excellent >90
No. of certified buildings	563,461	110,315	1201	1
In Turkey	43	242	1	1

1.2. Research Objectives

This paper aims at i) investigating the situation of certified green buildings according to their distribution, certification level, and project types; and ii) presenting the more and less problematic categories and criteria to obtain credits. In contrast to above-mentioned studies in Turkey, larger sample size, i.e., 242 LEED, 43 BREEAM, 1 DGNB and 1 CEDBIK-certified green buildings, will be taken into consideration in this study. The results of this research can be useful to understand the situation of certified green projects in Turkey, and to point out the assessment categories that show higher or lower difficulty in earning credits. In this way, it can be understood which categories need further attention from the policymakers and design teams to obtain more credits in future projects.

2. METHODOLOGY

This research is organized into two main sections. In the first section, general statistical data related to 242 LEED, 43 BREEAM, 1 DGNB, and 1 CEDBIK-certified green buildings are illustrated. Later on, descriptive statistical analysis of credit achievements based on project types and rating categories of 127 LEED new construction certified projects is conducted. This paper focuses on LEED new construction system because i) this system is the well-developed versions of LEED [23], ii) the majority of green buildings in Turkey were certified under this system, iii) the data related to these projects were accessible online, and iv) the total number of projects certified by the newest version, i.e., LEED v4, at the time of the research was small. The small sample size can produce significantly biased results. Besides, LEED v.2009 is the first version of LEED that includes regional priority credits.

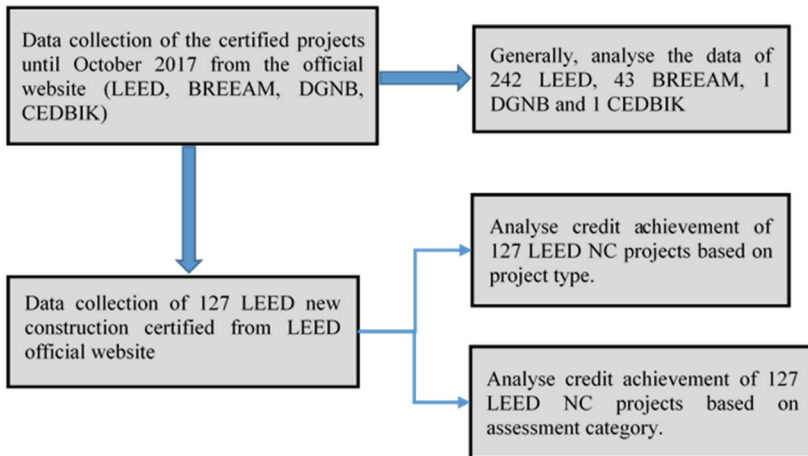


Figure 2 - Flowchart of the methodology

The analysis of this version can help to understand the performance of regional priority credits. On the other hand, the data related to BREEAM, DGNB, and CEDBIK-certified projects are partially reachable. The data used in the present study were retrieved from the official green building rating systems' websites in the directory of certified projects located in Turkey until October 2017. The general data (i.e., project name, total earned points, location, accredited date etc.) related to LEED-certified projects were retrieved in an excel spreadsheet downloaded from the official website [30]. Furthermore, the credit achievements in various categories for each project were obtained from the official website in the directory of certified projects located in Turkey [31]. The information about BREEAM, DGNB, and CEDBIK-certified projects were also collected from their official websites in the directory of certified projects located in Turkey [32-34]. Figure 2 presents the flow chart of the methodology followed in this study.

3. RESULTS AND DISCUSSIONS

3.1. General Statistical Data of the Certified Projects in Turkey

There were 242 LEED, 43 BREEAM, and 1 DGNB-certified projects at the time of the research conducted. Geographical distribution of LEED, BREEAM, DGNB, and CEDBIK-certified projects in Turkey is given in Fig. 3. Furthermore, Fig. 4 shows the percentage distribution of certified buildings according to geographical regions of Turkey. Turkey is located partly in Asia and partly in Europe and acts as a bridge between the two continents. The area of Turkey is divided into seven geographical regions according to their climate, location, flora and fauna, human habitat, agricultural diversities, transportation, topography and other characteristics.

The distribution of green building examples is in a linear relationship with the economic and demographic development of these geographical regions. It can be seen from Figs. 3- 4 and even from the literature [27, 30] that certified green buildings are mostly located in the western region of Turkey while there is a lack of certified green buildings in its other regions.

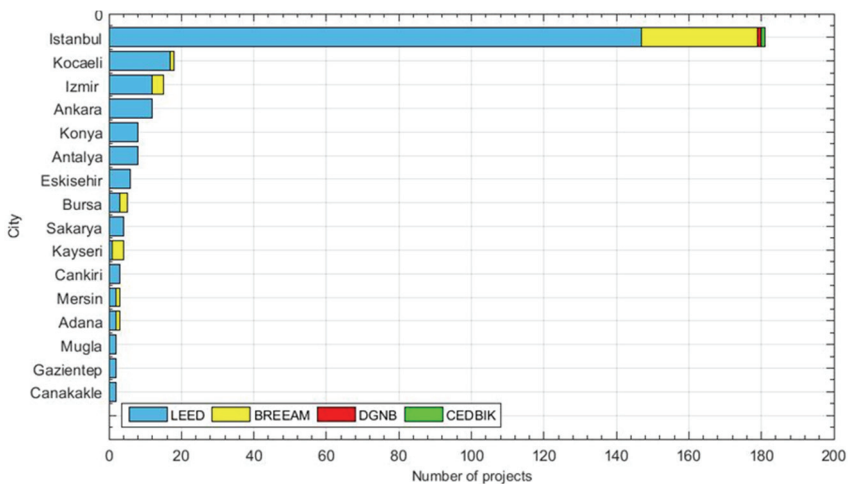


Figure.3 - Geographical distribution of certified projects



Figure 4 - Distribution of certified buildings in Turkey's geographical regions

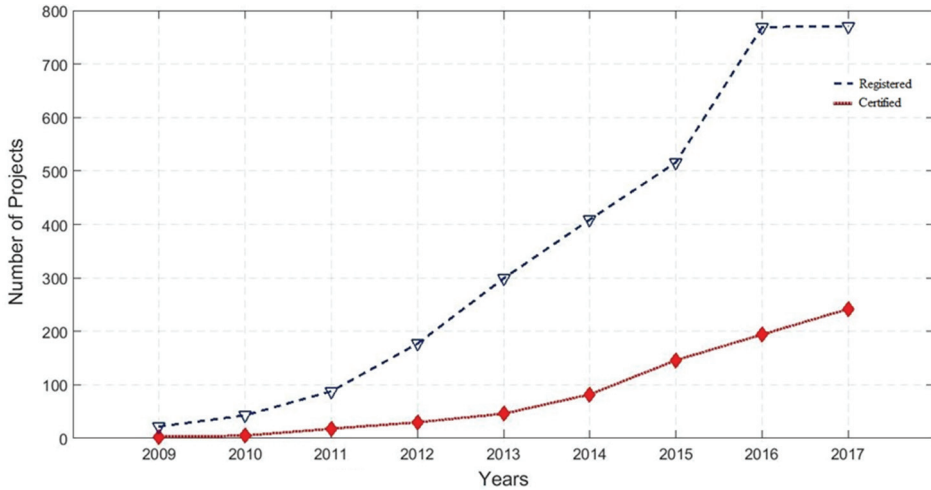


Figure 5 - Cumulative number of registered and certified LEED projects in Turkey

Aktas and Ozorhon [35] as well as Uslu et al. [36] concluded that investors operating in big cities are more willing to embrace green policies, and in addition to the aforementioned benefits, obtaining an international certificate for their buildings is used as a powerful tool to increase competitiveness in the market.

There was only one DGNB-certified project, a commercial building with a gold certificate and located in Istanbul, the most populated city of Turkey. Besides, there is a residential building that has a very good certification level located in Istanbul, certified by CEDBIK. Comparing the number of projects qualified by BREEAM, DGNB, and CEDBIK, the numbers of LEED-certified projects are higher. The certified and registered numbers of

LEED projects are illustrated by years in Fig. 5. The percentages of LEED projects under different version and scheme in Turkey are given in Fig. 6. It can be observed from Fig. 6 that the projects were mainly certified under LEED v.2009 version and new construction scheme.

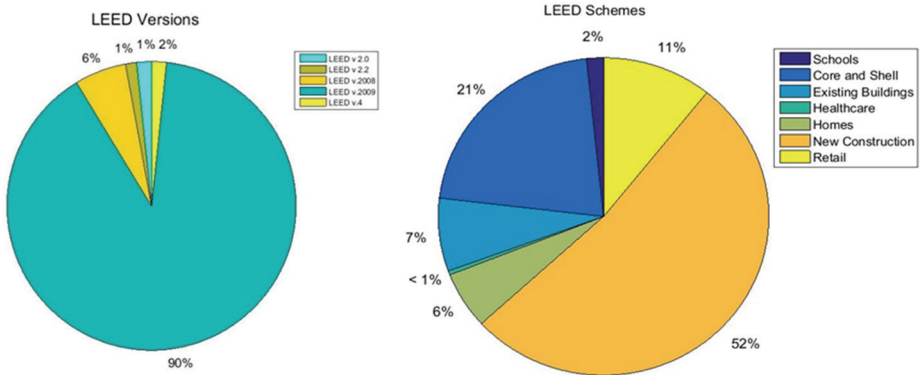


Figure 6 - The percentage of LEED-certified projects according to LEED version and scheme

BREEAM-certified projects in Turkey were evaluated under its international scheme. Their distribution according to the project types and phases is given in Fig. 7. Even in the BREEAM system, the dominating scheme is new construction. In addition, office and retail project types are encountered at a higher percentage. The distribution according to the level of certification is presented for LEED and BREEAM systems in Fig. 8. It is seen from Fig. 8 that most of LEED-certified projects have scored a total of 60-79 credits while most of BREEAM-certified projects were rated very good that means 55-70% accomplishment of total possible points was achieved.

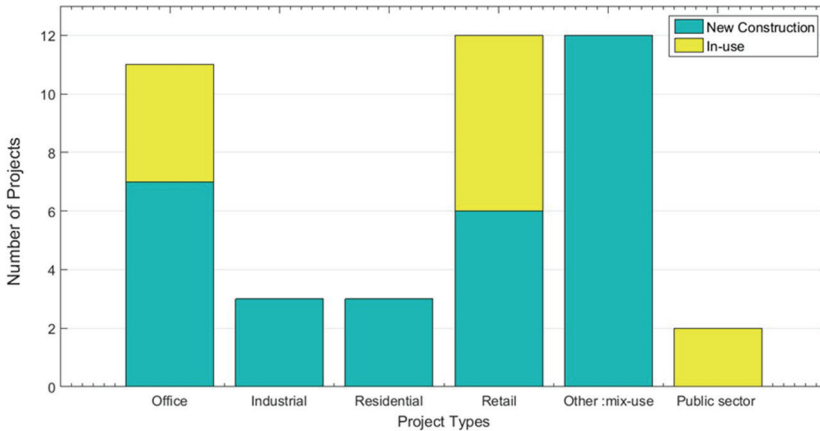


Figure 7 - BREEAM projects according to the project scheme and type

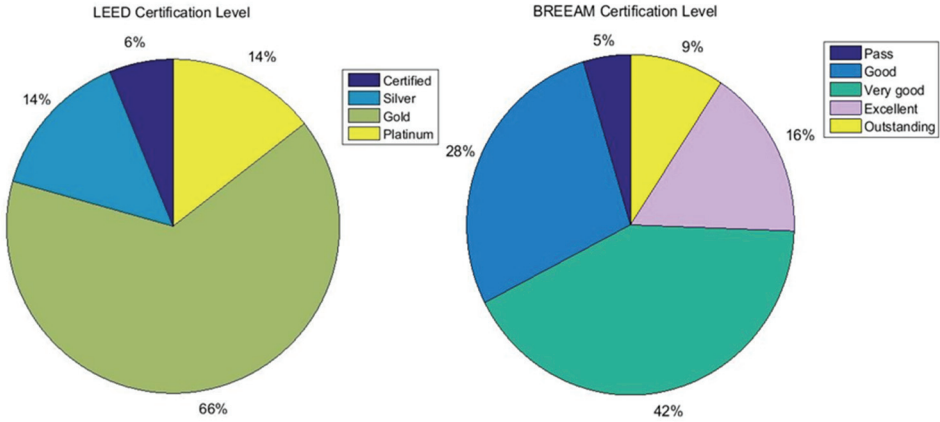


Figure 8 - LEED and BREEAM certification category distribution

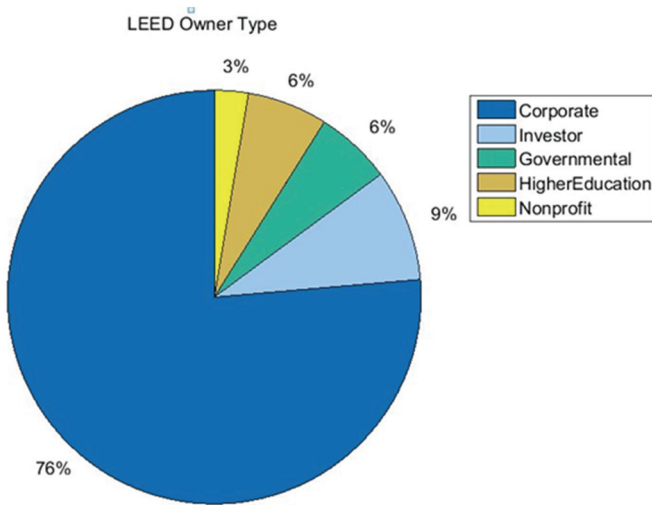


Figure 9 - Owner types in the LEED system

Fig. 9 shows the type of owners and their percentage for LEED-certified projects. It is understood that the private companies are more willing to invest in green buildings. Also, higher education institutions have invested in greener campus. This leads to increase indoor environmental quality as well as the productivity of occupants [35]. Even governmental authorities in Turkey are engaged in building more energy efficient offices and reducing the operational cost. Due to high level of electricity consumed for lighting purposes (20%), the Ministry of Energy and Natural Resources initiated the policy on “Transition to Efficient Public Lighting” to reduce the electricity bills in public institutions [37, 38].

3.2. Analysis of LEED New Construction Projects Based on Project Type

In this section, 127 LEED new construction certified projects were analysed. Only three of them are certified under LEED v2.2 version but the others are certified according to LEED V.2009. The LEED new construction scheme is selected for further analysis because this scheme is the most well-developed evaluation scheme and has a higher number of samples. A histogram is depicted in Fig. 10 for the frequency of points obtained by the projects under this scheme. As demonstrated in the histogram, the most frequently acquired points vary from 60 to 65. The distribution according to the project types is illustrated in Fig. 11. It can be assumed from Fig. 11 that office projects tend to be more certified due to lower payback value [39]. Also, office projects have a higher range of total earned credit with an average of 67.4. Higher operational cost characterizes this type of projects. Therefore, it is in the investor's benefit to increase the percentage of improvement in respective categories. Despite presenting 80% of the total building stock in Turkey, the certified residential building consists of only 17% of total certified projects [40].

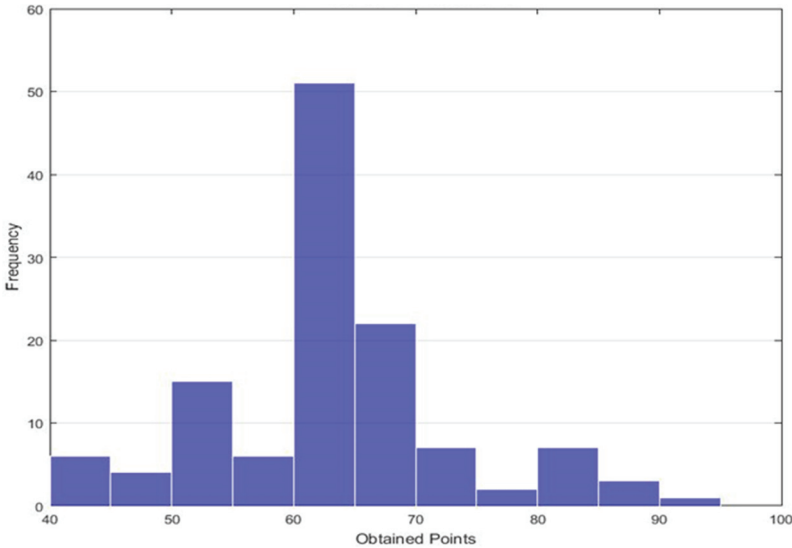


Figure 10 - Histogram of frequency of obtained points in the LEED New Construction

Fig. 12 is schematized according to data retrieved by [31, 41], and shows the percentage of improvement in different categories for each project type. The rate of improvement is calculated as a division of the project's performance with reference building's performance (as required in the LEED system) for a particular aspect. Each bar in Fig. 12 indicates the average percentage of improvement in each criterion for the corresponding project type.

In Figure 12, the numbers inside the bars represent the number of projects showing improvement in the related criterion. The average credit achievements of each project type in the associated categories are tabulated in Table 2. In projects like retail, office public

assembly, lodging (i.e., hotels, resorts), and core learning space, a generation of 5-13% onsite renewable energy is noticed.

Based on Figure 12 and Table 2, these projects are mainly located in metropolises, namely Istanbul, Ankara, Bursa, Çanakkale, Mersin, and Izmir. For the same category of project's type, a green power purchase of 35% is seen, but the number of projects is small, which are located in Istanbul, Bursa, Antalya, Mersin, and Izmir. They utilize renewable energy from green power plants, which mostly are found in the Mediterranean region.

For the material category, it can be implied that a maximum of 20% of recycling content of building materials is achieved for most of the project types. Also, locally produced materials are used in the same percentage. A higher percentage of improvement is reached in the subcategory division of construction and demolition debris, approximately 75%. Generally, an undesired performance is noticed in the following subcategories: reuse of existing building material, existing interior non-structural elements, and existing building structures and envelope. In these subcategories, only a limited number of projects have achieved a percentage of improvement of 50, 50, and 85%, respectively. Unfortunately, even the use of FSC-certified products and rapidly renewable materials are noticed in limited projects and in low percentages. In the indoor environmental quality category, in most of the project types, 75% of occupied spaces have daylight and 90% of live-in areas has a quality view. In the water efficiency category, an average reduction of 80% in potable landscape water use, 38% in indoor water use, and 50% in wastewater generation was achieved.

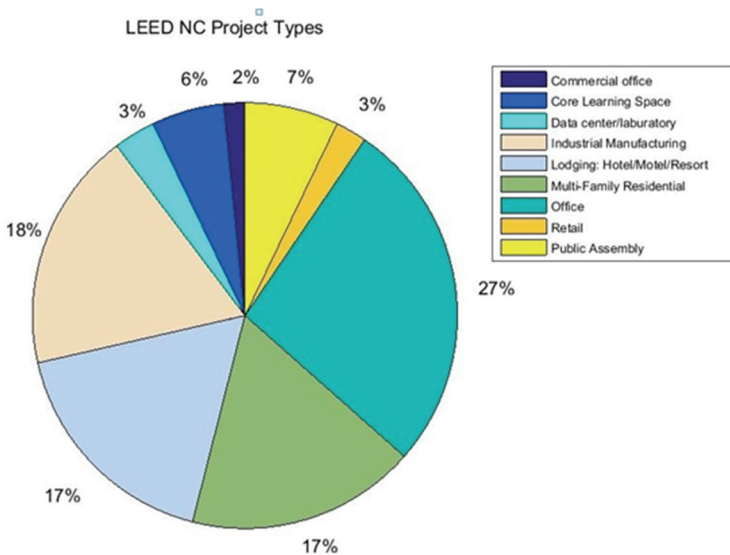
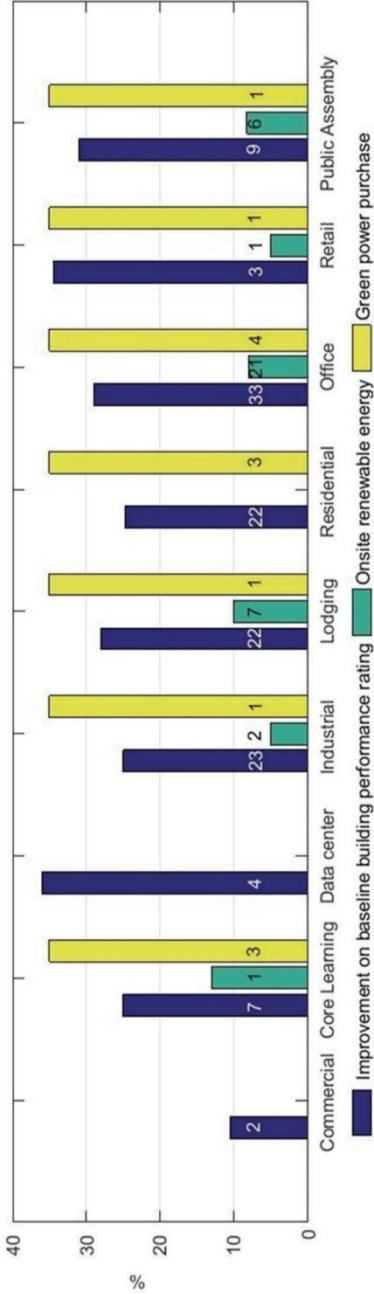
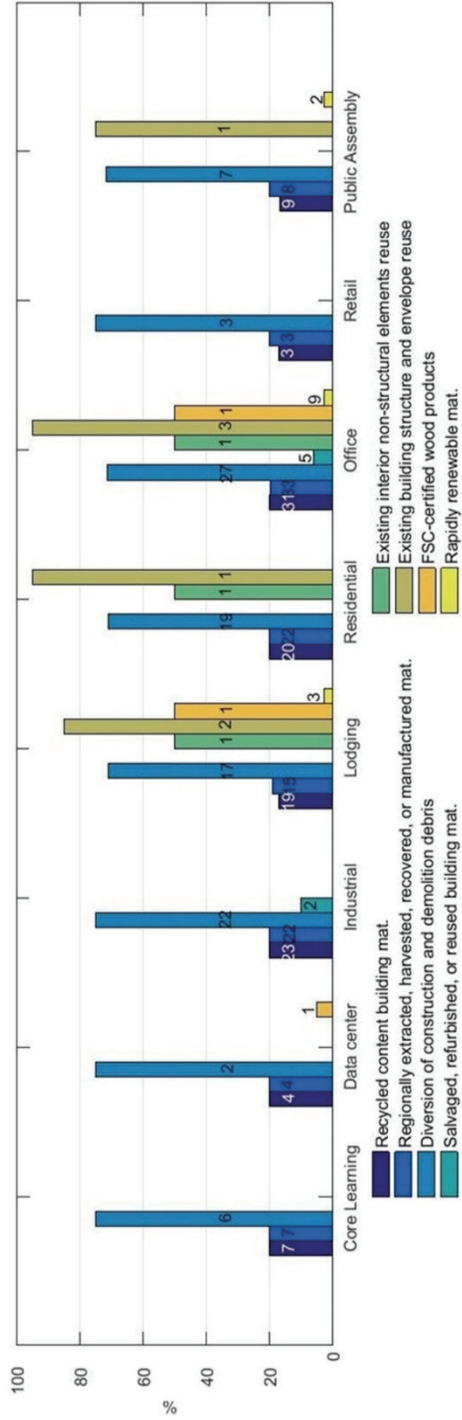


Figure 11 - The distribution of LEED New Construction projects according to project type



a) Energy & Atmosphere Category



b) Material & Resources Category

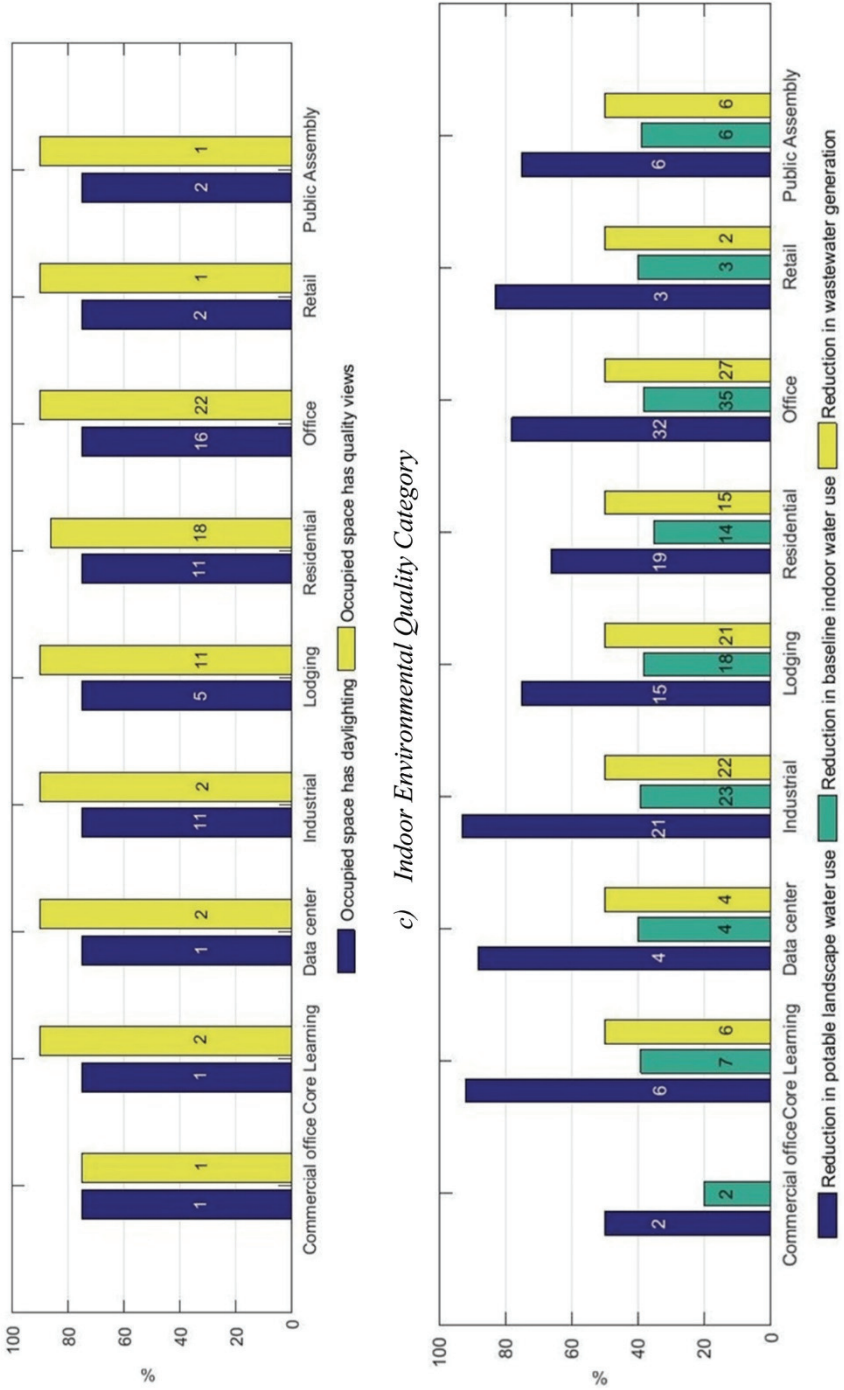


Figure 12 - The percentage of improvement in a) energy & atmosphere; b) material & resources; c) indoor environmental quality; and d) water efficiency categories for various project types

Table 2 - Average point obtained for each project type in every category

Category	Commercial office	Core Learning	Data center	Industrial	Lodging	Residential	Office	Retail	Public Assembly
Total average point	43	64.7	74	59.5	58	57.5	67.4	67.4	63.2
Sustainable site	9	20.3	20	16.5	18.9	19	19	18.3	20.2
Water efficiency	4.5	8.6	9.5	9.2	6.7	5.3	8	9.3	7.5
Energy & atmosphere	7.5	13.9	20.7	12.6	13.4	11.7	16.8	16.7	15.9
Indoor environmental quality	12	7.1	9.5	7.4	6.9	7.9	9	9.7	6.5
Material & Resources	6	5.7	5.25	5.6	4.8	5.5	6	5.7	5.3
Innovation	4	5.6	5.75	4.9	3.9	5	5	4	4.6
Regional Properties	-	3.6	3.25	3.3	3.5	3	3.6	3.7	3

3.3. Analysis of LEED New Construction Projects Based on Categories

For projects certified under LEED BD+C New Construction (NC), an investigation of most and least credit earned categories is conducted. Table 3 presents the information about the average percentage of credit secured by the LEED NC-certified projects in the following categories: regional priorities, innovation, water efficiency, sustainable site, indoor environmental quality, energy & atmosphere, and material & resources. Also, the most problematic and non-problematic criteria are highlighted.

Table 3 - Percentage of credit achievement in different categories of LEED NC-certified project

Category	Possible point	Average point	%	Level of difficulty	Subcategory	%
Regional priority	4	3.37	84	Less	Optimize energy performance	85
					Heat island effect - roof	54
				Higher	Construction waste management	1
					Site development - protect or restore habitat	1
Innovation	6	4.77	80	Less	Innovation in design	76
					LEED Accredited Professional	100

Table 3 - Percentage of credit achievement in different categories of LEED NC-certified project (continue)

Category	Possible point	Average point	%	Level of difficulty	Subcategory	%
Water efficiency	10	7.68	77	Less	Innovative wastewater technologies	85.5
				Higher	Water efficient landscaping	68.5
					Water use reduction	80.6
Sustainable site	26	18.69	72	Less	Alternative transportation	91.5
					Heat island effect -	81
				Higher	Brownfield redevelopment	0
Indoor environmental quality	15	7.88	52	Less	Construction IAQ management plan-during construction	85.5
					Low-emitting materials - paints and coatings	88.7
				Higher	Low-emitting materials - composite wood and agrifiber products	5.6
					Low-emitting materials - flooring systems	25.8
Energy& atmosphere	35	14.48	41	Less	Enhanced refrigerant management	71.8
					Measurement and verification	80
				Higher	On-site renewable energy	18.9
Material & Resources	14	5.54	40	Less	Green power	14.5
					Recycled content	89
					Regional materials	91
				Higher	Building reuse (maintain interior non-structural elements; maintain existing walls, floors, and roof)	4
					Certified wood	2.4
	Materials reuse	4				

Wu et al. [23] investigated the credit achievements of LEED v.2009 certified projects, 89 in Turkey, 172 in China, and 75 in Brazil, respectively. While comparing the results of the present study with that of the above research, it can be concluded from Table 4 that the average credit achievement of the certified projects in Turkey in each category does not change with the increase of certified projects number.

Table 4 - Comparison of the results

Category	Possible point	Present study results	Wu et al. [23]
Innovation	6	4.77	4.58
Water efficiency	10	7.70	7.63
Sustainable site	26	18.69	18.80
Indoor environmental quality	15	7.88	7.88
Material & Resources	14	5.44	5.51
Energy& atmosphere	35	14.48	14.33

Analysis of the categories in a descending order based on the average percentage of credit achievement is discussed as follows:

Regional priority category shows an average percentage of 84% in credit achievement. From 4 possible credits, an average of 3.3 credits was obtained. Regional priority credits for LEED v.2009 scheme set by the USGBC for all the projects in Turkey include 2 credits concerning energy conservation, 1 credit for thermal comfort verification, 1 credit for recycling of non-structural materials, 1 credit for quantity control of storm water, and 1 credit for minimizing heat island effects [12]. While, in LEED v.4, generally for Turkey, criteria evaluated under regional priority category are the thermal comfort, sensitive land protection, reduced parking footprint, site development-protect or restore habitat, open space, rainwater management. The respective regional priority credits changed in different regions of Turkey because of LEED v.4, the assignment of regional priority credits is made based on geocoding. However, during the examination of credits earned in this category, the credits were attributed even in other criteria such as construction waste management and site development-protect or restore habitat.

Innovation category shows an average percentage of 84% in credit achievement. During the LEED certification process, the requirement of a LEED Accredited Professional is obligatory, that's why the fulfillment of this criterion was 100%. Also, in the other criterion of this category, a considerable average percentage of 76% was achieved. This high rate implies extensive implementation of innovative design techniques in the certified green building projects.

Water efficiency category shows an average percentage of 77% in credit achievement. Considering the growing population of Turkey and being a water-stressed country, the implementation of water conservation measures is necessary to reduce the demand for potable water. Some of the strategies used in these projects to earn credits in this category are the installation of low flow fixtures, rainwater harvesting system, greywater recycling, and water-wise landscaping [42].

Sustainable site category shows an average percentage of 72% in credit achievement. The majority of the projects are located in high-density urban zones. This creates the opportunity to easily reach a larger number of amenities and low-carbon public transportation vehicles around the projects site [43]. Consequently, it can be earned without any difficulty credits in this category. However, none of the buildings has gained points in the brownfield re-development sub-category. This situation may be driven by a lack of adequate policies which

can encourage the third parties to invest in the conversion of the brownfields through appropriate treatments to suitable construction sites.

Indoor environmental quality category shows an average percentage of 52% in credit achievement. In this category, some of the most important aspects of health and well-being of a person take place like air quality, thermal comfort, daylight availability and quality view. This moderate rate of achievement is not insufficient to ensure a healthy lifestyle considering that in the modern lifestyle a person spends approximately 90% of the time indoors [44, 45]. That's why, designing with green principals plays a positive role in reducing the rate of respiratory disease, sick building symptoms, and enhance occupant comfort and worker performance [46].

Material & Resources category shows an average percentage of 40% in credit achievement. This low rate indicates the handicap of the sustainable construction material supply chain and Construction and Demolition Waste (C&DW) recycling systems. One of the fundamental principles of sustainability is the responsible use of available resources reflected even in certification systems by encouraging the selection of eco-friendly and recyclable materials and appropriate waste management planning. Previous surveys in Turkish green construction industry pointed out the immaturity of sustainable material manufacturing industry and the lack of incentives for construction waste management as one of the reasons of the low performance in this category [47, 48]. Furthermore, Ulubeyli et al. [48] pointed out the limited number of C&DW recycling plants in Turkey. There are only two plants owned by private enterprises and one by Istanbul Municipality. The development of C&DW can be useful in the reduction of recycling process cost, reversing the adverse impact on the environment by reducing the transportation distance from construction site to the recycling plant and increasing awareness at the architect and contractors about salvaged and recycled building materials [49]. These obstacles have a negative impact on the initial cost of the projects and discourage investors to embrace green construction [50, 51].

Energy & Atmosphere category shows an average percentage of 41% in credit achievement. Despite the high importance showed by the government and the academic authorities toward minimization of non-renewable energy demand and encouraging onsite renewable energy, the average credit achievement in this category was not at the desired level. While performing an investigation for renewable energy performance for various countries, Arik [52] concluded that Turkey showed a good level for renewable energy incentives from the government like the enacting of the second Renewable Energy Law, namely Law No. 6094 in 2010 concerning the use of Renewable Energy Resources for the Generation of Electrical Energy. Unfortunately, for further development of renewable energy production, it is necessary to use a better electric power grid. Also, the absence of adequate binding policies and financing options possibilities for sustainability of renewable energy was pointed out even by Gurgun and Arditi [53]. Unfortunately, Turkey imports 72.5% of the total energy used, but the investments in renewable energy productions like 41 wind farms intend to lower this percentage [38]. Except for wind energy, there is a great possibility to produce geothermal energy and solar energy in Turkey, but it is required more attention and support from the government. Another criterion in this category that shows a low average percentage of achievement is green power purchasing. This result is incurred by the lack of green-certified renewable energy grid-source [53].

Table 3 points out the more promising criteria to earn more credits for projects located in Turkey. In this way, the design team during the certification process can focus on these criteria to increase the likelihood of higher certification rate. However, indoor environmental quality, energy & atmosphere, and material & resources categories are essential for designing and constructing a greener project, and further attention should be paid by the practitioners to improve the performance of their projects in categories [54].

The low percentage of credit achievement in particular categories implies the lack of proper green building development incentives and binding regulations by the policymakers to increase the opportunities to obtain higher certification level and consequently greener projects.

4. CONCLUSIONS

In the last decade, interest towards implementing green construction practice and the number of certified green buildings in the Turkish market has increased. In this study, a general overview of 287 certified green buildings was provided. Furthermore, the average credit achievement of 127 LEED new construction certified projects was investigated based on project types and assessed categories. Some of the key findings are:

- The examples of green buildings were mostly concentrated in densely populated and industrialized cities, especially in the western part of Turkey but in the eastern part of Turkey, the examples of green projects are rare.
- Project types characterized by high operational costs showed a higher certification level.
- The investigation performed for 127 certified projects under LEED v.2009 NC scheme indicated fewer credits earned categories and revealed the problematic criteria that hinder the acquiring of higher certification level.
- Even though the number of certified projects in Turkey has increased, the comparison of the present study results with the available ones demonstrated there is no improvement of average credit achievements in related categories.
- The categories showing lower average percentages in credit achievements for indoor environmental quality, energy & atmosphere, and material & resources are 52, 41, and 40%, respectively.
- Some criteria such as brownfield redevelopment, low-emitting materials, on-site renewable energy, materials reuse etc., are denoted as no inconsiderable level of credit achievements.

Knowing the updated LEED-certified projects performance at a country level orientates the policymakers to establish proper green building development incentives and binding regulations. Also, it can be implied from the results that further effort should be made by the practitioners during design stage to improve the performance of their projects in important categories such as indoor environmental quality, energy & atmosphere, and material & resources.

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