ITU A|Z • Vol 18 No 1 • March 2021 • 139-152

LEED certified mixed-use residential buildings in Istanbul: A study on category-based performances

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Received: December 2019 • Final Acceptance: September 2020

Abstract

The building industry has a significant negative effect on climate change and increases other environmental problems at the global scale. LEED, which is one of the most globally used environmental assessment tool, provides the certification of projects according to the evaluation criteria of green buildings under certain categories. On the other hand, an emerging form of architecture, the mixed-use residential high-rise building (MRB), appears in larger numbers especially in the metropolitans of developing countries, such as Istanbul. This building typology displays a positive approach in the context of sustainability. Since they are high-budget projects addressing to high-income groups, it is inherently expected that they have a green approach as a social responsibility. The objective of this study is to analyze LEED certified MRBs in Istanbul by focusing on their prioritization of evaluation categories. LEED's database revealed a total of twenty-one certified projects under the New Constructions (v.3) scheme. Based on the gained points by these projects, mean rank values of the evaluation categories were calculated, which indicated the priorities given by this sample group. Furthermore, the conducted Kruskal-Wallis test showed there was highly significant difference among the rankings of the categories for these projects. Based on these rank order tests, obtained category priority order of MRBs was compared to the one implied by LEED's assigned category weights. It was found that Energy and Atmosphere category gained much lower attention than required. Taking the results of the study into account, certain conclusions were drawn for this building type in Istanbul.

Keywords
Green building rating systems, LEED, Assessment category, Mixed-use, Residential buildings.

doi: 10.5505/itujfa.2020.35002

1. Introduction

Today, it is a well-known fact that the building industry is largely responsible of the global environmental impact as well as a considerable part of health related problems. Around 40% of the total global energy demand and material use is due to construction activities (Erlandsson & Borg, 2003). Buildings consume 12% of potable water and 55% of wood products, while they account for 30% of greenhouse gas (GHG) emissions and generate around 55% of the waste sent to landfills (Castro-Lacouture, Sefair, Flórez, & Medaglia, 2009). Moreover, indoor environments which do not comply with green building practices may cause severe effects on human health, known as the Sick Building Syndrome (Castro-Lacouture et al., 2009). However, it also is a field where significant improvement on the issue has been and is continuing to be accomplished (Zabalza Bribián, Aranda Usón, & Scarpellini, 2009).

There have been continuous efforts to find solutions for mitigating these problems through green building practices and technologies (Cole, 1999, 2005; Crawley & Aho, 1999; Ding, 2008). Green building principles help conduct resource efficient design and construction, improve performance throughout operation and reclaim wastes at the end of life phases of buildings (Greer et al., 2019). Therefore, one of the most important tools to tackle these mentioned problems is the Green Building Rating Systems (GBRS).

On the other hand, as a solution to overpopulation and housing shortage in urban areas, MRB projects have been increasing in numbers especially in cities of developing countries with high population densities. Istanbul is one example to these cities where such high-rise developments arise significantly owing to its recent advancements in the real estate sector and growing financial centres. Having the highest population of over 15 million, Istanbul has always been a metropolitan with the highest demand and sales numbers for housing in Turkey (TUIK, 2019). It should also be noted that there is a considerable and increasing demand for green building certification in this city. As of 14 July 2019, there are a total of 245 LEED, BREEAM and EDGE certified projects in Istanbul, of which 210 are LEED certified (CEDBIK, 2019). Hence, this paper analyses LEED certified MRB projects in Istanbul, regarding their prioritization of green building assessment categories.

1.1. Aim and scope of the study

The main aim of this study is to find out to what extend above mentioned LEED certified green projects in Istanbul comply with the priority order of evaluation categories set forth by LEED authorities. Therefore, the study presents the assessment of these projects based on their performances in LEED evaluation categories and provides insights for this building typology in Istanbul, by comparing the category priority order revealed by the project performances to the order adopted by the LEED system.

As to the version of LEED, although the latest version of the system is version 4 (v.4), version 3 (v.3) was chosen for the analysis in the study due to the lack of certified MRB projects in version 4 and the abundance of them in version 3 in Istanbul.

The issue of 'Mixed-use Residential Buildings' has often been examined as to its economical aspects in studies particularly in the field of real-estate; and as to its social and environmental aspects in the fields of urban planning, architecture and interior architecture. In the literature, the mentioned topic has been dealt with from various points of view, such as economic efficiency,contributing factors (Rabianski and Clements, 2007; Rabianski et al., 2009), public welfare (Akgün, 2010), human health and social well-being (Barros et al., 2019), the relationship between architectural design approach and user behaviour (Goodman, 2008; Zengel and Deneri, 2007) and architectural language (Aslankan, 2019). However, as it was mentioned in a comprehensive literature study conducted on the topic (DeLisle and Grissom, 2013), this issue was examined mostly from the aspects of scale, usage of site, urban form and finance. It is seen that studies which analyze the issue from the aspects of sustainability and green architecture are rather less and the existing examples have dealt with it mostly from energy perspective. Moreover, in research involving case studies it is seen that the green features of buildings have been reported (Şahin and Hocaoğlu, 2015), or parameters such as location, spatial analysis, relationship with environment, function ratios (Sarı, 2006) and urban design (Hocaoğlu, 2014) have been evaluated. In this context, the present study has an original contribution to the literature since it provides the analysis of MRBs with a holistic approach based on their performances in green building assessment categories of LEED and the evaluation of findings based on the conditions of Istanbul.

Moreover, although publications on green building rating systems, particularly on LEED have appeared in the literature often, none of them solely examine the performances of certified MRB projects in Istanbul based on assessment categories and present an in-depth analysis on the underlying reasons of poor category performances. Hence, the scope of this study can be summarized as;

i) Finding out mixed-use residential high-rise buildings in Istanbul which have completed LEED NC v.3 certifications and listing their certification details

ii) Gathering achieved points by these projects under each category from LEED's database

iii) Finding out category scores and calculating mean rank values by the conducted rank order tests

iv) By the conducted Kruskal-Wallis test, revealing that there was highly significant difference among the rankings of the categories

v) Establishing a priority order among the categories based on the conducted rank order test

vi) Comparing the priority order of categories derived from the projects' performances with the order set forth by LEED authorities

vii) Based on the findings, drawing certain conclusions for this building typology in Istanbul

Therefore, this analysis serves as a guide for those researchers interested and professionals involved in green building rating systems, as well as authorities associated to the construction industry particularly in Turkey.

2. Mixed-use residential high-rise buildings

Residential environment, which is an essential component of the urban fabric, constitutes the highest percentage of urban settlements (Oktay, 2001; Skalicky & Čerpes, 2019a). Since residential environments have a central position in an individual's life by being a fundamental aspect of daily routine and providing comfort and security, the psychological and social importance of housing is undeniable. In these environments, the relationships between the user, the building and the society are so crucial that when the compatibility between these elements gets weaker, physiological and psychological problems, as well as social disorders may arise (Oktay, 2001; Vliet, 1999).

The continuously growing migration from rural to urban areas, leads to the increase of urbanization globally. It is estimated that by 2050, 70% of the world population would be living in urban areas (Skalicky & Čerpes, 2019b). In the light of this projection and the awareness of the environmental impact of urban sprawl, also as to the fact that land becoming scarce and expensive in urban areas, there is a tendency towards compact, high-rise developments (Ahmad, Aibinu, & Thaheem, 2017; Barros et al., 2019; Wener & Carmalt, 2006). A significant number of researchers and policy makers suggest higher-density tall urban developments as a means of sustainability, since they optimize land use while leaving more ground surfaces for green areas and other amenities (Yuen, 2005; Zengel & Deneri, 2007). However, since high-rise developments are massive structures designed to serve large populations, these buildings are often associated with high levels of resource consumption. They entail large amounts of material consumption during construction, exhaust water and energy resources during operation, and produce significant amounts of waste at their end of life phases (Ahmad et al., 2017; Wener & Carmalt, 2006). However, the insight of assuming high-rise buildings as less sustainable might be overstated since studies to verify this hypothesis which analyses the issue in a holistic context hardly exists in literature (Ahmad et al., 2017). It should be acknowledged that this issue comprises many parameters which may also have positive effects on sustainability. In fact, a study focusing on the spatial distribution of population has found that when population and income levels were kept constant, carbon emissions were lower in urban areas when compared to rural areas, where there are lower population densities (Ahmad et al., 2017; Glaeser & Kahn, 2010).

On the other hand, in numerous studies it is stated that high-density mixed-use developments affect social wellbeing positively by providing socially cohesive environments and lessen energy consumption by promoting walking, cycling and public transportation (Bentley, Alcock, Murrain, McGlynn, & Smith, 1985; Jacobs, 1961; Mouratidis, 2018; Murrain, 1996). Therefore, in the field of planning, the recent trend has shifted from 'massive and repetitive housing blocks… towards a rich variety of…mixed-use developments' (Oktay, 2001).

Together with these arguments and increasing globalization, a new hybrid form of building typology, namely, mixed-use residential high-rise building (MRB) has emerged for users who wish to keep up with the fast urban life. It should be noted that there is no internationally accepted definition of a high-rise building (Al-Kodmany, 2018). In this study, MRB is defined as a multi-storey building including various facilities, with its primary use being residential. Therefore, MRBs consist of not only dwellings, but also some other public services, such as; fitness centres, shopping malls, cafes and restaurants. As these buildings accommodate various facilities in a single entity, they also act as semi-public spaces (Zengel & Deneri, 2007). Moreover, since the residents have the opportunity to access a variety of amenities within their residential buildings, MRB projects help to reduce the extra carbons to be emitted for transportation. In this context, this building typology can be deemed sustainable, since it embraces an inclusive design approach within the society, sets a good example for local self-sufficiency and help lessen environmental impacts.

According to Sev, mixed-use developments should be supported as users have the opportunity to meet various needs close to their place of habitation (Sev, 2009). By integrating a number of uses in a single location, this typology also provides flexibility to adapt buildings according to changing demands, thus increasing its long term life-cycle. It is also stated that MRBs would help improve social relations and enhance social values. Moreover, they would yield to full-time occupancy of spaces and therefore provide more security for their users (Sev, 2009). However, from another point of view, MRBs have negative effects on the transportation in their area, as these complexes easily become a place of attraction for citizens (Zengel & Deneri, 2007).

Karakus states that, in the past, the guiding principles for the production of high quality housing were mostly shaped by functionality and aesthetics. Yet today, the guidelines for designing urban housing which require high density solutions are based on promoting sustainable communities (Karakuş, 2009). Within this framework, this high-cost building typology is expected to have a green design approach as a social responsibility. Therefore, this study has been carried out considering the importance of assessing the performances of MRBs regarding green building rating systems.

3. Green building rating systems

Since green buildings provide energy, water and material conservation, economic savings, as well as, healthy and high-quality spaces; they have gained considerable public support and have become the major pioneering field in sustainable development (Ali & Al Nsairat, 2009). There are numerous environmental building assessment tools used worldwide. Most of these tools are developed nationally and used internationally across the globe. However, only some are subjected to customization for international use, according to changing local conditions (Süzer, 2015).

3.1. LEED

The US-originated Leadership in Energy and Environmental Design (LEED) is considered to be one of the two most prominent and widely used environmental assessment tools at the global scale (Wu, Mao, Wang, Song, & Wang, 2016). Since it was developed in 2000 by the US Green Building Council (USGBC), it gained tremendous popularity and became a credible guide to implement and assess green building practices beyond its country of origin (Süzer, 2015). As of 3 July 2019, there are 103052 LEED certified projects worldwide (USGBC, 2019a).

LEED offers the assessment and certification of various project types under its different schemes. Each scheme contains certain evaluation categories and under these categories there are credits to be fulfilled with assigned points. Projects are evaluated based on their performances and awarded simply according to their total gained points. If the project receives a score between 40-49 points it is awarded as Certified, if it gets points between 50-59 it is certified as Silver, if it gets points between 60-79 it is granted Gold, and finally if it receives a score higher than 80 it gets Platinum award (Horvat & Fazio, 2005; Süzer, 2015; USGBC, 2009, 2019b).

Since the day LEED was first launched as its pilot version v1.0, it has been continuously updated to address current needs and building technologies accurately and upgraded regarding its assessment methods and used standards, under the names v2.0, v2.2, v.3 (also known as version 2009) and v.4, successively. The currently used version v.4 was launched on 11 January 2019 (USGBC, 2019b) and lately a Beta version which is v.4.1 was launched in April 2020. The categories and credit weights included in each scheme and version differ partly as the system goes under such revisions (USGBC, 2020).

4. Methodology

As to the analysis of the study, for gathering data on projects, LEED's online project database was used (USGBC, 2019a). The various schemes offered by LEED and their field of use are as follows (USGBC, 2019b):

- BD+C: Building Design and Construction, including New Construction (NC), (for New Constructions and Major Renovations),
- ID+C: Interior Design and Construction, for complete interior fit-out projects
- O+M: Building Operations and Maintenance, for existing buildings
- ND: Neighbourhood Development, for new land development projects
- Homes: For single family, low and mid-rise multi-family homes (up to six stories)
- Cities and Communities: For entire cities and sub-sections of a city
- LEED Recertification: For projects previously achieved LEED certification
- LEED Zero: For projects with net zero goals in carbon and/or resources

For the analysis, as to the LEED scheme, New Constructions and Major Renovations (NC) was chosen. The reason for selecting the NC scheme is due to the fact that this scheme covers the building typology which is the main subject of the paper and offers a more extensive field of use when compared to other schemes, therefore gives higher certification numbers when MRB projects are considered (USGBC, 2019a).

Moreover, as to the version of LEED, version 3 (v.3) was chosen for the analysis in the study. Although the latest version of the system is version 4 (v.4), LEED's database revealed that, out of a total of 42 projects registered for certification under the NC v.4 scheme in Istanbul, only 5 of them have a completed certification and neither one can be classified as an MRB project. On the other hand, its previous version, v.3 was launched in 2009, however, it has a significant number of registered projects in Istanbul, some of which are still under the certification process (USGBC, 2019a).

From the search on LEED's project directory, by using the search filters of; v.3 as the version, New Constructions as the scheme and Istanbul as the city, the database gave the results of a total of 210 projects. It was seen that, out of these 210 registered projects, only 66 of them had a completed certification. After careful screening of these results, it was seen that, out of 66, 21 projects could be identified as MRBs (USGBC, 2019a). It is important to underline that more than one-thirds of the LEED NC (v.3) certified projects in Istanbul is composed of MRBs.

The certification scores of these 21 projects were used for the analysis of this study. Moreover, it was noticed that out of the 21 projects, 5 of them had received separate certifications for their building blocks which yielded to the increase of the sample size to 35 for the conducted statistical analysis. The details of the mentioned projects and their code numbers are presented in Table 1.

LEED NC v.3 scheme is composed of five main categories which are; (i) Energy and Atmosphere (EA), (ii) Sustainable Sites (SS), (iii) Indoor Environmental Quality (IEQ), (iv) Materials and Resources (MR) and (v) Water Efficiency (WE). The total points assigned to the credits presented under each category make up a total of 100 base points. The additional two categories of evaluation are Innovation and Regional Priority, which add extra 10 bonus points (USGBC, 2009). The certification process simply involves the summation of achieved points for each credit, under each category. The point allocation system for the credits found under each category is based on scientific studies and the consensus of LEED authorities. These credit points entail an implicit weighting system among the categories of evaluation, as they display a certain weight within the total 100 base points and thus imply a priority among these categories (Horvat & Fazio, 2005; Süzer, 2015).

Table 1. *Details of LEED NC (v.3) certified MRB projects in Istanbul (USGBC, 2019a).*

#	Project Code	Name of Project	Overall Score (Out of 110)	Certification Level	Year of Certification	Reference
1	1a	Agaoglu Maslak 1453 A Blok	60	Gold	2017	
2	1b	Agaoglu Maslak 1453 B Blok	63	Gold	2018	(Ağaoğlu, 2019a)
3	1c	Agaoglu Maslak 1453 C Blok	61	Gold	2017	
4	2	And Pastel Turuncu	66	Gold	2018	(Anadolu Grubu, 2019)
5	3	Andromeda Gold Residence	61	Gold	2013	(Ağaoğlu, 2019b)
6	4	Cinar Apartmani	63	Gold	2018	(BB Yapı, 2019)
7	5	Daire Kartal	62	Gold	2018	(Kale, 2019)
8	6	Dumankaya Flex Kurtkoy	50	Silver	2014	(Dumankaya, 2019)
9	7	Istanbloom	63	Gold	2015	(Esin Yapı, 2019)
10	8	Maltepe Piazza Residence	62	Gold	2019	(Rönesans Gayrimenkul, 2019)
11	9a	Metropol Istanbul A Block	60	Gold	2017	
12	9b	Metropol Istanbul B Block	62	Gold	2017	("Metropol İstanbul", 2019)
13	9c	Metropol Istanbul C1 Block	62	Gold	2017	
14	10a	Narlife A Block	60	Gold	2016	
15	10b	Narlife B Block	60	Gold	2016	(Tepe İnşaat, 2019)
16	10c	Narlife C Block	61	Gold	2015	
17	11	Nidapark Seyrantepe	63	Gold	2018	(Tahincioğlu, 2019)
18	12	Rings Office Suites	60	Gold	2017	(Çevredostu, 2019)
19	13	Selenium Retro	60	Gold	2018	(Aşçıoğlu, 2019)
20	14a	Soyak Konforia Block A	51	Silver	2018	
21	14b	Soyak Konforia Block B	51	Silver	2018	("Soyak Konforia", 2019)
22	14c	Soyak Konforia Block C	51	Silver	2018	
23	15	Soyak Soho	63	Gold	2014	(Soyak Yapı, 2019)
24	16	Sunsetpark Caddebostan	45	Certified	2017	(Kentpark Yapı, 2019)
25	17	Tekfen Bomonti Apartments	63	Gold	2012	(Tekfen Realestate, 2019a)
26	18a	Tekfen Hep Istanbul B2	54	Silver	2018	
27	18b	Tekfen Hep Istanbul B3	55	Silver	2018	
28	18c	Tekfen Hep Istanbul B4	56	Silver	2018	
29	18d	Tekfen Hep Istanbul B5	55	Silver	2018	(Tekfen Realestate, 2019b)
30	18e	Tekfen Hep Istanbul B8	55	Silver	2018	
31	18f	Tekfen Hep Istanbul B10	54	Silver	2017	
32	18g	Tekfen Hep Istanbul B11	52	Silver	2017	
33	19	The House Residence	66	Gold	2017	(Yenigün, 2019)
34	20	Yildiz 45	64	Gold	2018	(Yıldız Yapı Grubu, 2019)
35	21	42 Maslak Tower A	55	Gold	2015	(Yeşil Bina Dergisi, 2016)

Table 2. LEED NC v.3 main category weights and priority order.

Category	Weighting		Priority Order
Energy and Atmosphere	35 points	35%	1
Sustainable Sites	26 points	26%	2
Indoor Environmental Quality	15 points	15%	3
Materials and Resources	14 points	14%	4
Water Efficiency	10 points	10%	5
Total	100 base points		

The weighting system of LEED NC, v.3 for its categories and hence their priority order are given in Table 2 (USGBC, 2009).

In the current study, as to the method of analysis firstly the score details of LEED certified MRB projects in Istanbul were collected from LEED's project database (USGBC, 2019a). To find out the Category Scores (CS) of the projects, the Achieved Points (AP) by the projects under each category were divided by the Total Available Points (TAP) allocated to the categories by LEED (Table 2). The calculated CS values $(\bar{R})$ are given in Table 3.

Secondly, by using these CS values, rank-order tests were conducted to assess the priority order among these groups of data. The CS values were sorted in ascending order, so that each value was assigned a rank that indicated where in the order it appeared (Argyrous, 2011). After that, the mean rank values were calculated for each category. Higher the mean rank value meant higher success, thus higher priority given to that category. It was found that, the mean rank $(\bar{R})$ value of the Energy and Atmosphere category

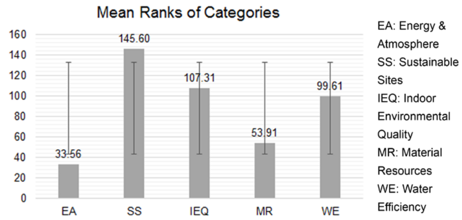

Figure 1. *Mean rank values of assessment categories of MRB projects.*

Table 3. *Calculated Category Score (CS) values of MRB projects.*[1,2]

Project Code	EA AP	EA TAP	EA CS	SS AP	SS TAP	SS CS	IEQ AP	IEQ TAP	IEQ CS	MR AP	MR TAP	MR CS	WE AP	WE TAP	WE CS
1a	15	35	0.43	16	26	0.62	9	15	0.60	6	14	0.43	6	10	0.60
1b	15	35	0.43	18	26	0.69	9	15	0.60	6	14	0.43	6	10	0.60
1c	12	35	0.34	17	26	0.65	9	15	0.60	6	14	0.43	8	10	0.80
2	15	35	0.43	23	26	0.88	8	15	0.53	5	14	0.36	8	10	0.80
3	11	35	0.31	22	26	0.85	8	15	0.53	6	14	0.43	4	10	0.40
4	8	35	0.23	23	26	0.88	10	15	0.67	6	14	0.43	8	10	0.80
5	10	35	0.29	23	26	0.88	9	15	0.60	6	14	0.43	6	10	0.60
6	11	35	0.31	14	26	0.54	7	15	0.47	4	14	0.29	6	10	0.60
7	13	35	0.37	23	26	0.88	7	15	0.47	4	14	0.29	8	10	0.80
8	9	35	0.26	22	26	0.85	9	15	0.60	5	14	0.36	10	10	1.00
9a	8	35	0.23	21	26	0.81	11	15	0.73	6	14	0.43	6	10	0.60
9b	9	35	0.26	21	26	0.81	12	15	0.80	6	14	0.43	6	10	0.60
9c	9	35	0.26	20	26	0.77	11	15	0.73	6	14	0.43	7	10	0.70
10a	14	35	0.40	16	26	0.62	7	15	0.47	6	14	0.43	7	10	0.70
10b	13	35	0.37	16	26	0.62	9	15	0.60	6	14	0.43	7	10	0.70
10c	15	35	0.43	16	26	0.62	8	15	0.53	6	14	0.43	7	10	0.70
11	14	35	0.40	21	26	0.81	9	15	0.60	5	14	0.36	6	10	0.60
12	9	35	0.26	22	26	0.85	7	15	0.47	6	14	0.43	6	10	0.60
13	18	35	0.51	16	26	0.62	7	15	0.47	7	14	0.50	4	10	0.40
14a	9	35	0.26	15	26	0.58	10	15	0.67	6	14	0.43	4	10	0.40
14b	10	35	0.29	14	26	0.54	10	15	0.67	6	14	0.43	4	10	0.40
14c	10	35	0.29	14	26	0.54	10	15	0.67	6	14	0.43	4	10	0.40
15	14	35	0.40	21	26	0.81	6	15	0.40	5	14	0.36	8	10	0.80
16	10	35	0.29	19	26	0.73	7	15	0.47	2	14	0.14	2	10	0.20
17	11	35	0.31	23	26	0.88	7	15	0.47	6	14	0.43	6	10	0.60
18a	11	35	0.31	20	26	0.77	8	15	0.53	5	14	0.36	2	10	0.20
18b	10	35	0.29	20	26	0.77	8	15	0.53	5	14	0.36	4	10	0.40
18c	11	35	0.31	20	26	0.77	8	15	0.53	5	14	0.36	4	10	0.40
18d	10	35	0.29	20	26	0.77	8	15	0.53	5	14	0.36	4	10	0.40
18e	11	35	0.31	20	26	0.77	8	15	0.53	5	14	0.36	4	10	0.40
18f	9	35	0.26	20	26	0.77	8	15	0.53	5	14	0.36	4	10	0.40
18g	9	35	0.26	20	26	0.77	8	15	0.53	4	14	0.29	4	10	0.40
19	12	35	0.34	22	26	0.85	10	15	0.67	3	14	0.21	10	10	1.00
20	11	35	0.31	20	26	0.77	9	15	0.60	8	14	0.57	6	10	0.60
21	22	35	0.63	15	26	0.58	8	15	0.53	6	14	0.43	4	10	0.40

Category Scores (CS) = Achieved Points (AP) / Total Available Points (TAP)

[1]Project code numbers 1, 9, 10, 14 and 18 have separate certifications for their different building blocks, noted here as a, b, c, etc.

[2]EA: Energy and Atmosphere, SS: Sustainable Sites, IEQ: Indoor Environmental Quality, MR: Materials and Resources, WE: Water Efficiency, AP: Achieved Points, TAP: Total Available Points, CS: Category Score

was 33.56, Sustainable Sites was 145.60, Indoor Environmental Quality was 107.31, Materials and Resources was 53.91 and finally, Water Efficiency was 99.61 (see Fig. 1).

To see statistically, if some categories received much more attention than others, or if there was a rather more uniform distribution of rankings throughout the groups, a Kruskal-Wallis (KW) test was conducted (Table 4). According to the KW test, it was seen that there is highly significant difference among the rankings of the categories ($p < 0.001$).

Table 4. *Kruskal-Wallis test conducted on CS values of MRB projects.*

	EA	SS	IEQ	MR	WE	
median	0.31	0.77	0.53	0.43	0.60	
rank sum	1174.5	5096	3756	1887	3486.5	
count	35	35	35	35	35	175
r^2/n	39413	741978	403072	101736	347305	1633504
H-stat						108.43
H-ties						108.96
df						4
p-value						1.E-22
alpha						0.05
sig						yes

Hence, based on the results of the Kruskal-Wallis test, it was concluded that it is possible to establish a hierarchy order among the category performances of the projects. As mentioned before, mean rank values for the category scores found by the conducted rank order test revealed the priority order of the categories regarding the performances of MRBs. Due to the fact that category scores were sorted in ascending order; higher mean rank values indicated higher success, thus higher priority. Hence, the category order for the projects was determined as; first Sustainable Sites, second Indoor Environmental Quality, third Water Efficiency, fourth Materials and Resources and finally fifth, Energy and Atmosphere (Fig. 2). Consequently, the priority order established by these projects was compared with the order set forth by LEED, using its implicit category weightings (Fig. 2, Table 2). Based on this comparison, by detecting which categories gained higher importance and which ones were overlooked (or found fewer opportunities for application), discussions were made and certain conclusions were derived for this building typology.

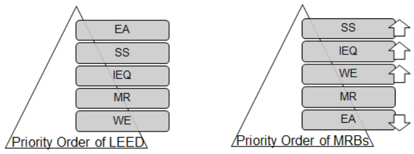

Figure 2. *Comparison of the priority order of categories according to LEED weightings (left) and MRB projects results (right).*

5. Findings and discussion

As mentioned above, the hierarchal order of categories in LEED, which is implied by their weights, is based on the consensus regarding the severity of the global environmental problems. Hence, the most important assessment category in LEED and other widely used green building rating systems across the world is associated with energy due to the issue of climate change (Sallam & Abdelaal, 2016). It is a well-known fact that today the most alarming environmental problem the world is facing is global warming stemming from the excessive emission of harmful gases because of the increased usage of fossil fuels instead of renewable resources. However, the findings of this study show that the category with the lowest mean rank value, which is 33.56, is Energy and Atmosphere for these projects, in stark contrast to LEED's proposal. EA lies at the bottom of the hierarchy pyramid as the last environmental concern for these projects while it stands as the first category for the LEED system (Fig. 2). This implies that EA category has not achieved enough emphasis as required and displayed the weakest performance in the applications of MRB projects.

The reason for this finding is believed to be mostly related to economic concerns. In their study, Wu et al. underlined that credits of EA, such as; '…optimized energy performance through energy modelling (EAc1), on-site renewable energy (EAc2) and enhanced commissioning (EAc3) are believed to be the biggest added expenses for LEED projects' (Wu et al., 2016). Furthermore, in another study it is stated that, LEED does not accredit passive design applications and therefore achieving a high score in EA category is not possible unless mechanical systems are used (Santos, Samani, & de

Oliveira Fernandes, 2018). Hence it is believed that new credits accrediting passive design strategies could be integrated into the system so that decision makers would be encouraged to foster energy efficiency and achieve higher scores under this category through these strategies without the necessity of high cost mechanical systems.

In parallel to LEED's order, due to the current problems of Istanbul, such as; extreme population density, irregular urbanization, squatter settlements, urban sprawl, lack of green areas, as well as, heavy traffic because of the insufficient and inefficient public transportation services (Süzer, 2012), SS can be rightfully considered as the second most important category. Since this category is found to be in the first place regarding projects' performances, it can be understood that the required emphasis was given to this category and a satisfactory result was achieved.

Since the category of IEQ, located at the third place in LEED's order is found at the second place for the MRB projects, it can be derived that needed emphasis was given to this issue. However, considering the LEED evaluation criteria under this category, related to the selection of indoor finishing materials regarding Volatile Organic Compound (VOC) emissions, it can be stated that there is still a lack of availability of suitable certified materials in the local market in Turkey (Süzer, 2012). Moreover, as imported certified materials would increase emissions of GHGs for transportation, it would serve against the principal of using local materials. Yet, in the future, it is expected that recently increasing awareness can promote the production of such materials locally.

When the MR category is examined, it is seen that in both of the hierarchal pyramids its position is stable, as the fourth category. Furthermore, other studies in literature have also indicated that MR and EA categories, which are also the categories with the two lowest performances in the present study, are the most difficult ones to obtain credits in the evaluation process (Moussa & Farag, 2017; Wu et al., 2016). This issue is believed to be related to certain applicability problems such as, difficulties in reaching certified building materials and products, and lack of availability of the market for green technologies, as mentioned above (Moussa & Farag, 2017).

Yet, it is important to note that, the Turkish construction materials industry is a net exporter sector ("Turkiye IMSAD", 2017), therefore, the abundance of local construction materials for the projects constitute a positive aspect considering this category. On the other hand, regarding the waste management approach in the city, it is seen that landfill is the most widely practiced method ("IBB Kati", 2010). However, according to the EU, it is the least preferred option in the waste management hierarchy ("Being wise", 2010). Furthermore, LEED does not audit the waste management policies of localities. Hence, even though projects might include amenities for the separation of wastes, the lack of effective recycling programs of municipalities or private establishments would make these applications useless.

Finally, it is seen that WE, the last important category in LEED's order takes place in the third row in MRB pyramid and indicates that sufficient performance was achieved. Yet, it should be noted that together with the newly supplied water resources in Istanbul, the municipality can hardly meet the current demand of the city's population (ISKI, 2019). Another problem is that there is a significant amount of generated waste water and a very high portion of it is discharged into receiving environments ("ISKI Stratejik Plani", n.d.). Therefore, since it is often pointed out that the emerging global crisis will be related to the scarcity of water resources (Jury & Vaux, 2007), considering the increasing population density in the city, this issue may constitute a severe problem in the future.

6. Conclusion

This paper analyzes LEED certified MRBs in Istanbul as to their performances in environmental assessment categories, with the aim of finding out if they comply with the priority order of categories asserted by LEED authorities. By using the category-based scores of these projects, the conducted rank order tests, namely; calculating the mean rank values and performing a Kruskal-Wallis test on them revealed that the level of compatibility between the results derived from the projects and LEED's proposal are quite low.

Green building industry is considered as the flagship of sustainable development today and its most important environmental issue is based on minimizing energy consumptions, providing energy conservation and using renewable resources in these buildings. Yet, the findings of this study show that energy issue has turned out to be the last concern for the analysed LEED certified MRB projects in Istanbul. This finding reveals the fact that energy is the most critical issue for this building typology and Turkey needs to take action particularly as it has always been a country dependent on foreign energy resources (Sen, Günay, & Tunç, 2019). When the import figures are examined, it is seen that the greatest current deficit is always related to the energy expenditures (Munir, 2012).

In fact, Istanbul and overall Turkey have an advantageous location, as to benefitting from renewable energy resources (Erbil, 2011). Due to factors such as, being close to the equator and taking sun rays perpendicularly, as well as having long hours of insolation throughout the year, Turkey has a high potential for the use of solar energy (Erbil, 2011). Furthermore, regarding geothermal energy resources, Turkey is the seventh richest country in the world, and the first in Europe (Akpınar, Kömürcü, Önsoy, & Kaygusuz, 2008). As to wind energy, Turkey is considered to have a high potential as well. Istanbul, located at the coastal region of Black Sea and Marmara Sea, represent one of the most promising areas in Turkey with its wind densities (Ilkiliç & Aydin, 2015). Beside these advantages, the city can also benefit from tidal energy, since it is located at the Bosporus, where there are strong marine currents (Yazicioglu, Tunc, Ozbek, & Kara, 2016). It is stated that even though Turkey is a new actor in the renewable energy sector, it has been on the fast track in the past decade. Since Turkey is a net fossil-fuel importer, in order to decrease its dependence on such energy imports and improve its security, decision makers have been giving increasing emphasis on the issue. These efforts have also drawn the attention of the private sector companies in the country (Sen et al., 2019).

Yet, the problem of having EA category as the least priority for this building typology in Istanbul may be due to administrative difficulties and economic barriers in implementing effective green initiatives in Turkey. The initial investment costs of green systems and products are still very high in the country. To promote green initiatives, governmental tax incentives should be increased as in countries like Japan, UK or USA (KPMG-International, 2015). Furthermore, it should be pinpointed that green investments redeem their initial costs in the long term by providing energy savings. Thus, long term cost efficiency should be embraced as the project goal. Apart from the purpose of serving for public welfare, when evaluated from the commercial aspect, it should be noticed that energy related categories offer the possibility of providing the highest points in green building assessments.

As mentioned above, since MRB projects include various facilities and have high population densities, they consume significant amounts of energy. Therefore, in this building typology, using renewable and clean resources, providing energy efficiency and complete self-sufficiency are much more important compared to some other building types.

Together with certain improvements in Turkey and particularly in Istanbul, such as legislative regulations, the availability of the market for products or services increasing energy efficiency and the use of renewable energy resources, these rapidly multiplying high budget projects must be encouraged for displaying a higher performance in this fundamental category. Furthermore, to attain results more in-line with LEED priorities and to obtain more sustainable living environments, the awareness of decision makers, designers and investors on the issue should be increased.

References

Ahmad, T., Aibinu, A., & Thaheem, M. J. (2017). The Effects of High-rise Residential Construction on Sustainability of Housing Systems. *Procedia Engineering,* 180, 1695–1704. https://doi.org/10.1016/J.PROENG.2017.04.332

Ağaoğlu (2019a). Ağaoğlu Maslak 1453. Retrieved from http://www.maslak1453.com/en/ (accessed July 17, 2019).

Ağaoğlu, (2019b). Andromeda Gold. Retrieved from http://www.andromedagold.com/en/?pid=1 (accessed July 17, 2019).

Akgün, T. (2010). Karma işlevli yapıların kentsel ve mimari tasarım arakesitinde kamu yararı gözetilerek irdelenmesi: Zincirlikuyu-Levent aksı örneği. Istanbul: Istanbul Technical University

Akpınar, A., Kömürcü, M. İ., Önsoy, H., & Kaygusuz, K. (2008). Status of geothermal energy amongst Turkey's energy sources. *Renewable and Sustainable Energy Reviews,* 12(4), 1148–1161. https://doi.org/10.1016/J.RSER.2006.10.016

Ali, H. H., & Al Nsairat, S. F. (2009). Developing a green building assessment tool for developing countries – Case of Jordan. *Building and Environment,* 44(5), 1053–1064. https://doi.org/https://doi.org/10.1016/j.buildenv.2008.07.015

Al-Kodmany, K. (2018). The Sustainability of Tall Building Developments: A Conceptual Framework. *Buildings,* 8(1), 7. https://doi.org/10.3390/buildings8010007

Anadolu Grubu (2019). AND Pastel. Retrieved from https://www.andpastel.com/en/default.aspx (accessed July 17, 2019).

Argyrous, G. (2011). *Statistics for Research: With a Guide to SPSS.* SAGE Publications.

Aslankan, A. (2019). The production of urban and residential language by mixed-use mega projects in Istanbul. *Megaron*, 14(50), 1–10. https://doi.org/10.5505/megaron.2018.66199 (accessed November 14, 2019).

Aşçıoğlu (2019). Selenium Retro. Retrieved from http://www.seleniumretro9.com/en/residences (accessed July 17, 2019).

Barros, P., Ng Fat, L., Garcia, L. M. T., Slovic, A. D., Thomopoulos, N., de Sá, T. H., … Mindell, J. S. (2019). Social consequences and mental health outcomes of living in high-rise residential buildings and the influence of planning, urban design and architectural decisions: A systematic review. *Cities,* 93, 263–272. https://doi.org/10.1016/J.CITIES.2019.05.015

BB Yapı (2019). Konut Çınar. Retrieved from http://bbyapi.net/proje/konut-cinar (accessed July 17, 2019).

Being wise with waste: the EU's approach to waste management. (2010). https://doi.org/10.2779/93543

Bentley, I., Alcock, A., Murrain, P., McGlynn, S., & Smith, G. P. (1985). *Responsive Environments.* London: Architectural Press.

Castro-Lacouture, D., Sefair, J. A., Flórez, L., & Medaglia, A. L. (2009). Optimization model for the selection of materials using a LEED-based green building rating system in Colombia. *Building and Environment,* 44(6), 1162–1170. https://doi.org/10.1016/J.BUILDENV.2008.08.009

CEDBIK. (2019). Retrieved from https://cedbik.org/tr/sertifikali-projeler (accessed July 14, 2019).

Cevredostu (2019). Rings Office Suites. Retrieved from http://www.cevredostu.com/yesilbina/rings-office-suites/ (accessed July 17, 2019).

Cole, R. J. (1999). Building environmental assessment methods: clarifying intentions. *Building Research & Information,* 27(4–5), 230–246. https://doi.org/10.1080/096132199369354

Cole, R. J. (2005). Building environmental assessment methods: redefining intentions and roles. *Building Research & Information,* 33(5), 455–467. https://doi.org/10.1080/09613210500219063

Crawley, D., & Aho, I. (1999). Building environmental assessment methods: applications and development trends. B*uilding Research & Information,* 27(4–5), 300–308. https://doi.org/10.1080/096132199369417

DeLisle, J., & Grissom, T. (2013). An empirical study of the efficacy of mixed-use development: The seattle experience. *Journal of Real Estate Literature, 21* (1), 25-57. https://aresjournals.org/doi/abs/10.5555/

reli.21.1.jg22417188038vg2 (accessed November 15, 2019).

Ding, G. K. C. (2008). Sustainable construction—The role of environmental assessment tools. *Journal of Environmental Management,* 86(3), 451–464. https://doi.org/https://doi.org/10.1016/j.jenvman.2006.12.025

Dumankaya (2019). Flex Kurtköy. Retrieved from http://www.dumankaya.com/Projeler/YasamBaslayanProjeler/Flex Kurtköy (accessed July 17, 2019).

Erbil, A. Ö. (2011). Social acceptance of the clean energy concept: Exploring the clean energy understanding of Istanbul residents. *Renewable and Sustainable Energy Reviews,* 15(9), 4498–4506. https://doi.org/10.1016/J.RSER.2011.07.101

Erlandsson, M., & Borg, M. (2003). Generic LCA-methodology applicable for buildings, constructions and operation services—today practice and development needs. *Building and Environment,* 38(7), 919–938. https://doi.org/https://doi.org/10.1016/S0360-1323(03)00031-3

Esin Yapı (2019). Istanbloom. Retrieved from https://www.istanbloom.com/ (accessed July 17, 2019).

Glaeser, E. L., & Kahn, M. E. (2010). The Greenness of cities: Carbon dioxide emissions and urban development. *Journal of Urban Economics,* 67(3), 404–418.

Goodman, A. (2008). The residential mixed-use, urban infill project: Encouraging social interaction among baby boomers. Florida: Florida State University

Greer, F., Chittick, J., Jackson, E., Mack, J., Shortlidge, M., & Grubert, E. (2019). Energy and water efficiency in LEED: How well are LEED points linked to climate outcomes? *Energy and Buildings,* 195, 161–167. https://doi.org/10.1016/J.ENBUILD.2019.05.010

Hocaoğlu, P. (2014). Türkiye'deki karma kullanımlı yapıların kentsel tasarım ilkeleri doğrultusunda incelenmesi. Trabzon: Karadeniz Technical University Graduate School of Natural and Applied Sciences

Horvat, M., & Fazio, P. (2005). Comparative Review of Existing Certification Programs and Performance Assessment Tools for Residential Buildings. *Architectural Science Review,* 48(1), 69–80. https://doi.org/10.3763/asre.2005.4810

IBB Kati Atik Yonetim Mudurlugu Faaliyet Sunumu. (2010). Retrieved from ibb.gov.tr/sites/atikyonetimi/Documents/Faaliyet_sunumu.ppsx

Ilkiliç, C., & Aydin, H. (2015). Wind power potential and usage in the coastal regions of Turkey. *Renewable and Sustainable Energy Reviews,* 44, 78–86. https://doi.org/10.1016/J.RSER.2014.12.010

ISKI Stratejik Plani 2016-2020. (n.d.). Retrieved from http://www.sp.gov.tr/upload/xSPStratejikPlan/files/zIzke+ISKI_stratejik_plan_2016_2020_y.pdf

ISKI. (2019). Baraj Doluluk Oranları. Retrieved from https://www.iski.istanbul/web/tr-TR/baraj-doluluk-oranlari (accessed July 20, 2019).

Jacobs, J. (1961). *The Death and Life of Great American Cities.* New York: Random House.

Jury, W. A., & Vaux, H. J. (2007). The Emerging Global Water Crisis: Managing Scarcity and Conflict Between Water Users. *Advances in Agronomy,* 95, 1–76. https://doi.org/10.1016/S0065-2113(07)95001-4

Kale (2019). Daire Kartal. Retrieved from https://www.dairekartal.com/ (accessed July 12, 2019).

Karakuş, G. (2009). *Yüksek Yoğunluklu Konutlar.* (S. C. Duran, Ed.). İstanbul: YEM Publications.

Kentpark Yapı (2019). Sunsetpark Caddebostan. Retrieved from http://www.sunsetparkcaddebostan.com/ (accessed July 17, 2019).

KPMG-International. (2015). Taxes and Incentives for Renewable Energy. Retrieved from https://assets.kpmg.com/content/dam/kpmg/pdf/2015/09/taxes-and-incentives-2015-web-v2.pdf

Metropol İstanbul Yaşamın Merkezi, (2019). Retrieved from https://www.metropolistanbul.com/#page1 (accessed July 17, 2019).

Mouratidis, K. (2018). Built environment and social well-being: How does urban form affect social life and personal relationships? Cities, 74, 7–20. https://doi.org/10.1016/J.CITIES.2017.10.020

Moussa, R. A., & Farag, A. A. (2017). The Applicability of LEED of New Construction (LEED-NC) in the Middle East. *Procedia Environmental Sciences,* 37, 572–583. https://doi.org/https://doi.org/10.1016/j.proenv.2017.03.044

Munir, M. (2012, March 15). Cari Acik ve Enerji Politikasi. *Milliyet,* p. 12.

Murrain, P. (1996). Urban Expansion: Look Back and Learn. In R. Hayward & S. McGlynn (Eds.), *Making Better Places: Urban Design Now.* Oxford: Butterworth Architecture.

Oktay, D. (2001). *Planning Housing Environments for Sustainability: Evaluations in Cypriot Settlements.* Istanbul: YEM Publications.

Rabianski, J., Clemens, J. (2007). Mixed-use development: A review of professional literature. NAIOP Research Foundation.

Rabianski, J., Gibler, K., Tidwell, O., & Clements, J. (2009). Mixed-use development: A call for research. *Journal of Real Estate Literature, 17*(2), 205-230. www.jstor.org/stable/44105055 (accessed November 15, 2019).

Rönesans Gayrimenkul (2019). Piazza. Retrieved from http://www.ronesansmaltepe.com/en/ (accessed July 17, 2019).

Sallam, I., & Abdelaal, M. R. M. (2016). Relative weight of water efficiency credits: as an indicator to enhance buildings' environmental assessment tools performance. *Architectural Science Review,* 59(5), 423–431. https://doi.org/10.1080/00038628.2015.1107526

Santos, H., Samani, P., & de Oliveira Fernandes, E. (2018). Energy sufficiency in buildings, a synonym for passive and low energy architecture (PLEA). *Architectural Science Review,* 61(5), 292–297. https://doi.org/10.1080/00038628.2018.1505332

Sarı, B. (2006). İstanbul'da karma kullanımlı yüksek yapılar üzerine karşılaştırmalı bir irdeleme. İstanbul: Yildiz Technical University Graduate School of Science and Engineering

Sen, D., Günay, M. E., & Tunç, K. M. M. (2019). Forecasting annual natural gas consumption using socio-economic indicators for making future policies. *Energy,* 173, 1106–1118. https://doi.org/10.1016/J.ENERGY.2019.02.130

Sev, A. (2009). *Sürdürülebilir Mimarlık.* İstanbul: YEM Publications.

Skalicky, V., & Čerpes, I. (2019a). Comprehensive assessment methodology for liveable residential environment. *Cities,* 94, 44–54. https://doi.org/10.1016/J.CITIES.2019.05.020

Skalicky, V., & Čerpes, I. (2019b). Comprehensive assessment methodology for liveable residential environment. *Cities,* 94, 44–54. https://doi.org/10.1016/J.CITIES.2019.05.020

Soyak Konforia. (2019). Soyak Yapı. Retrieved from https://www.soyak.com.tr/soyak-konforia-bahcesehir-konut-projesi (accessed July 17, 2019).

Soyak Yapı (2019). Soyak Soho. Retrieved from https://www.soyak.com.tr/soyak-soho-zincirlikuyu-konut-projesi (accessed July 17, 2019).

Süzer, Ö. (2012). Karma kullanımlı çok katlı konut yapılarında sürdürülebilir tasarım kriterleri. Ankara: Hacettepe University Graduate School of Social Sciences

Süzer, Ö. (2015). A comparative review of environmental concern prioritization: LEED vs other major certification systems. *Journal of Environmental Management, 154,* 266-283. https://doi.org/10.1016/j.jenvman.2015.02.029 (accessed October 22, 2020).

Şahin, F., Hocaoğlu, P. (2015). Karma yapı tasarımları ve sürdürülebilir mimarlık. 2nd International Sustainable Buildings Symposium. Ankara: Gazi University.

Tahincioğlu (2019). Nidapark Seyrantepe. Retrieved from http://www.nidaparkseyrantepe.com/proje-hakkinda/ (accessed July 17, 2019).

Tekfen Real Estate Development (2019a). Bomonti Apartmanları. Retrieved from http://www.tekfen.com.tr/emlakprojedetay/4.html (accessed July 17, 2019).

Tekfen Real Estate Development (2019b). Hep Istanbul. Retrieved from https://hepistanbul.com.tr/en/ (accessed July 17, 2019).

TEPE İnşaat (2019). Narlife. Retrieved from http://www.tepe.com.tr/tr/taahhut/tamamlanan-projeler/ust-yapi/narlife-30-3-2018-17-16-21 (accessed July 17, 2019).

TUIK. (2019). Turkish Statistical Institute. Retrieved July 14, 2019, from http://www.turkstat.gov.tr/Start.do;jsessionid=VPgMdqrHPsFrp1QyplZHQw17yjW9JgQFMJhPH1bLjWhn4JLMg1t6!38629177

Turkiye IMSAD Yapi Sektoru Raporu. (2017). Retrieved from https://www.imsad.org/Uploads/Files/Turkiye_IMSAD_Yapi_Sektoru_Raporu2017.pdf

USGBC. (2009). LEED 2009 For New Constructions and Major Renovations. Retrieved from https://www.usgbc.org/resources/leed-new-construction-v2009-current-version

USGBC. (2019a). LEED Project Directory. Retrieved from https://www.usgbc.org/projects

USGBC. (2019b). LEED v4 for Building Design And Construction. Retrieved from https://www.usgbc.org/resources/leed-v4-building-design-and-construction-current-version

USGBC. (2020). Resources. Retrieved from https://www.usgbc.org/resources?LEED+Resource=%5B%22Rating+system%22%5D&Advocacy+Policy=%5B%22Rating+system%22%5D&Education+Resources=%5B%22Rating+system%22%5D&Credentialing+resources=%5B%22Rating+system%22%5D&Promotional=%5B%22Rating+system%22%5D&LEED+Resources=%5B%22Rating+system%22%5D

Vliet, W. van. (1999). *The Encyclopedia of Housing.* SAGE Publications.

Wener, R., & Carmalt, H. (2006). Environmental psychology and sustainability in high-rise structures. *Technology in Society,* 28(1–2), 157–167. https://doi.org/10.1016/J.TECHSOC.2005.10.016

Wu, P., Mao, C., Wang, J., Song, Y., & Wang, X. (2016). A decade review of the credits obtained by LEED v2.2 certified green building projects. *Building and Environment,* 102, 167–178. https://doi.org/https://doi.org/10.1016/j.buildenv.2016.03.026

Yazicioglu, H., Tunc, K. M. M., Ozbek, M., & Kara, T. (2016). Simulation of electricity generation by marine current turbines at Istanbul Bosphorus Strait. *Energy,* 95, 41–50. https://doi.org/10.1016/J.ENERGY.2015.11.038

Yenigün (2019). The House Residence. Retrieved from http://www.thehouseresidenceyenigun.com/iletisim.aspx (accessed July 17, 2019).

Yeşil Bina Dergisi (2016). LEED Gold Sertifikalı 42 Maslak A Kule. Retrieved from http://www.yesilbinadergisi.com/yayin/729/leed-gold-sertifikali-42-maslak-a-kule-_22201.html#.XS8JJ_IzbIU.

Yıldız Yapı Grubu (2019). Abdi İpekçi 45. Retrieved from http://yy-tr.com/en/ (accessed July 17, 2019).

Yuen, B. (2005). Romancing the high-rise in Singapore. *Cities,* 22(1), 3–13. https://doi.org/10.1016/J.CITIES.2004.10.002

Zabalza Bribián, I., Aranda Usón, A., & Scarpellini, S. (2009). Life cycle assessment in buildings: State-of-the-art and simplified LCA methodology as a complement for building certification. *Building and Environment,* 44(12), 2510–2520. https://doi.org/https://doi.org/10.1016/j.buildenv.2009.05.001

Zengel, R., & Deneri, B. (2007). Yükselen yapı bağlamında Türkiye'de kondominyumlara bir bakış. *Yapı Dergisi,* 32.