COMPARISON OF CERTIFIED „GREEN BUILDINGS" IN THE CONTEXT OF LEED CERTIFICATION CRITERIA

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PORÓWNANIE CERTYFIKOWANYCH "ZIELONYCH BUDYNKÓW" W KONTEKŚCIE KRYTERIÓW CERTYFIKACJI LEED

Abstract
The paper deals with the problem of "green building certification" compared with LEED certification criteria. The first part of the paper presents the need to use environmentally sensitive design and sustainability concepts today. Objectives for building certification such as minimizing energy consumption during building use, are explained. In order for the decisions of the architect and engineer to be aligned to this purpose in the building design process, appropriate values must be given to the design variables at various scales. According to these criteria, a large number of green building certification systems have been developed in the construction sector internationally and nationally in order to contribute to increasing the environmental performance of buildings. In the second part, selected buildings such as the Konya Science Center (2014) and the ArtScience Museum in Singapore (2011) are discussed. In this study, the concept of energy efficient green building design is questioned, information is given about Green Building certification systems and two examples have the same function and same certificate are examined in terms of LEED certification criteria. In the conclusion a comparative summary of data regarding the analyzed buildings is presented to show their common features regardless of the type of certification in a tabular comparison. The topic of the study is elucidated by using written sources, internet database and the information taken by state institutions. Furthermore, visual elements such as photos and tables have been used. The purpose of the study is to reveal that Green Building certification systems are used for annuity and prestige purposes. The importance of the assessments based on evaluation criteria and evaluation methods are highlighted in line with the definition of green building.

Streszczenie
Artykuł dotyczy problemu certyfikacji „Zielonych budynków" w porównaniu z kryteriami certyfikacji LEED. Pierwsza część artykułu przedstawia potrzebę zastosowania koncepcji projektowych wrażliwych na środowisko i zrównoważony rozwój. Wyjaśniane są cele certyfikacji budynku takie jak zminimalizowanie zużycia energii podczas jego użytkowania, bez wyrzeczeń w zakresie komfortu oczekiwanego przez użytkownika, co często jest problemem. Aby je osiągnąć wiele kryteriów i zmiennych o różnych wartościach i skalach powinno być uwzględnianych w procesie projektowym, zarówno przez architektów jak i przez inżynierów. Z uwagi na te kryteria w sektorze budowlanym opracowane zostały systemy certyfikacji dla „zielonych budynków" na poziomie krajowym i międzynarodowym. Mają one przyczynić się do podniesienia wrażliwości ekologicznej budownictwa. W części drugiej rozpatrywane są budynki takie jak Konya Science Center (2014) oraz ArtScience Museum w Singapurze (2011). Te dwa przykłady mają tę samą funkcję i ten sam certyfikat, co jest rozpatrywane pod kątem kryteriów certyfikacji LEED. Zweryfikowano koncepcję energooszczędnego projektowania budynków ekologicznych, podano informacje na temat systemów certyfikacji Green Building. W konkuzji przedstawiono zestawienie porównawcze danych dotyczących analizowanych budynków, aby wykazać ich wspólne cechy bez względu na rodzaj certyfikacji. Do porównań wykorzystano źródła pisane, internetową bazę danych i informacje podawane przez instytucje państwowe. Ponadto wykorzystywane są elementy wizualne, takie jak zdjęcia oraz tabele. Celem badania było wykazanie, że systemy certyfikacji Green Building są wykorzystywane do celów renty i prestiżu. Znaczenie ocen dokonanych na podstawie kryteriów oceny i metod oceny zostało podkreślone zgodnie z definicją zielonego budynku.

Keywords: energy efficiency; certification system; green building design

Słowa kluczowe: efektywność energetyczna; system certyfikacji; green building design

INTRODUCTION

As environmental pollution increases in the world, the main goal of all sectors has been to ensure that people can live healthily and improve the quality of the environment [A.B. Gültekin et al. 2006, p.2]. 50% of the energy consumed throughout the world is spent in the process of constructing and using buildings. Therefore, local authorities and professional groups constructing sector have a great responsibility in this regard. In this context, the concept of green building has been raised in the construction sector in recent years. Many certification systems are developed around the world, including LEED (America), BREEAM (Britain), Green Star (Australia), and these systems are also starting to be using in Turkey.

Konya Science Center, with the support of TUBITAK (The Scientific and Technological Research Council of Turkey) design, is an environmentally friendly, economical and healthy project that was built with regard to Green Building criteria. The Konya Science Center, designed with the criteria of LEED NC (Leadership in Energy and Environmental Design New construction) certification, is the first and only LEED NC Gold certified Science Center in Turkey.

Another green building is explored in this study which is the Singapore Artscience Museum. This building is another science building co-designed by Safdie Architects and Moshe Safdie and the same certified with LEED NC Gold. The ArtScience Museum is the first museum in the region to get this certificate in reducing environmental impact.

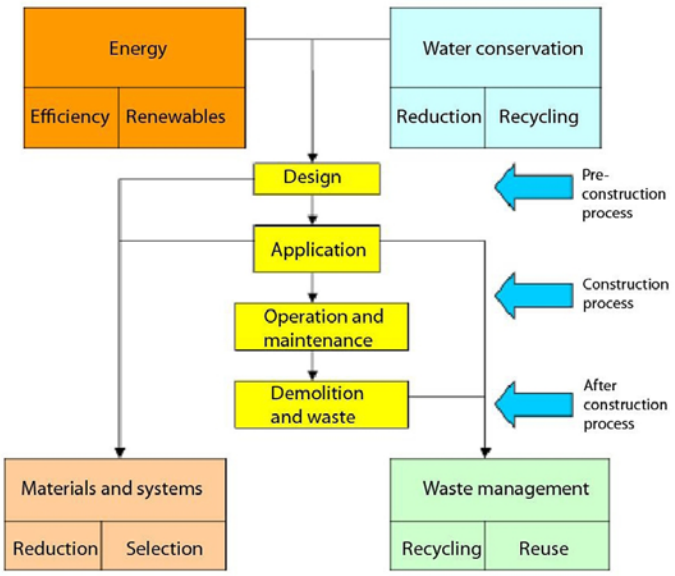


Fig. 1. Lifetime flow chart for buildings; source: J. Langmad 2004, B. Yılmaz 2009

1. GREEN BUILDINGS

Green buildings are constructed in order to reduce the whole effect of the built environment on human health and natural environment by efficiently using energy, water and other resources [S.B. Erdede et al. 2014, p.3]. Based on this goal, green buildings can be defined as energy-efficient structures that are respectful to nature and that are self-sufficient in order to benefit from nature at the highest level by using an infinite amount of resources.

Green buildings are part of the global response, an awareness of the growing role of human activity in causing global climate change. In addition many of the green buildings are high-tech real estate that takes into account the effects of buildings on the environment and human health. Besides, these buildings are structures that are directed towards renewable energy sources, providing recycling of waste water, benefiting from daylight as much as possible, having effective thermal insulation and producing the necessary energy. These goals can be achieved through better session (orientation of the building), design, material selection, construction, operation, maintenance, transport and possible reuse [J. Yudelson 2008, p.242], (Fig.1). Green buildings are built for these purposes:

- to protect the health of the inhabitants;
- to increase the efficiency of employees;
- using water, energy and other resources more efficiently;
- to minimize the negative environmental effects that may occur.

The World Commission on Environment and Development defined: *"Sustainability is to meet today's needs and expectations without jeopardizing the possibilities for future generations to meet their own needs"* in the Brundtland report [S.B. Erdede et al. 2014, p.5]. The concept of green building is more of a labelling task, apart from the concept of sustainable building. A sustainable building needs to meet certain criteria in order to become a green building. The concept of green building has been identified with certification systems. In addition, energy efficient building and high performance building concepts are used in the same sense as green building.

2. GREEN BUILDING CERTIFICATION SYSTEMS AND LEED CERTIFICATION SYSTEM

The environmental performance of a building can only be determined by a measuring system. Green Building certification systems can be defined as a type of rating system that seeks to provide a measurable reference in revealing the effects of building-based

projects on the environment and their sensitivity to protecting natural resources [E. Çelik 2009, p.13].

BREEAM (Bre Environmental Assessment Method) was created in the UK in 1990 and also this certification method is the first of its certification systems. Then, LEED was created in America, in 1998. In Canada SBTOOL, and in Hong Kong HK-BEAM, in Australia GREEN STAR, in Japan CASBEE are some of the other Green Building Assessment Systems [M. Anbarci et al. 2016, p. 378], (Fig.2).

The Energy Performance regulation in buildings was published in Turkey in 2008. It is aimed to use energy resources effectively and efficiently in buildings, to prevent energy waste and to protect the environment. BEP-HY(BEP Computing Method) is developed by the Ministry of Environment and Urbanism and this method shows how to calculate the amount of energy consumption per m^2 into per year and how to calculate CO^2 emissions of buildings covered by the energy performance in buildings (BEP) regulations. Using this calculation method, internet-based software called BEP-TR produces the appropriate energy Identification Certificate for the building as of 2010 [Energy Performance Regulation in Buildings 2008]. However, Breeam and Leed certification systems are the most common of these certification systems in the construction sector in Turkey. Table 1 shows the values of these two certificate systems [M. Sleeuw 2011, p.7].

- **LEED certification system**

LEED's goals are to develop a building design method by establishing measurement standards to identify Green Building, creating environmental leadership in the building industry, promoting green competition and also to raise consumer awareness about the benefits of green building.

The LEED green building rating system, which defines high-performance buildings that are economical with reducing operating costs by providing energy savings and respecting the environment by increasing

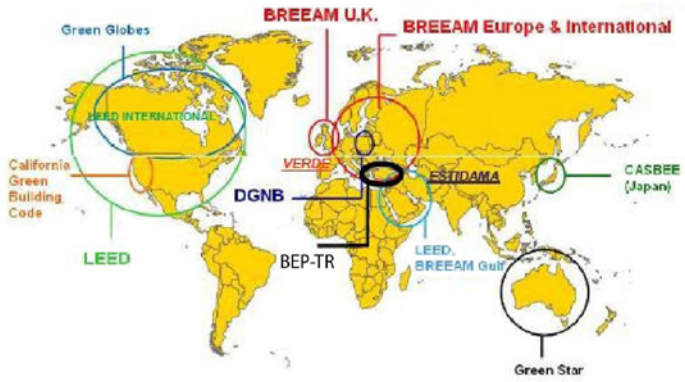


Fig. 2. International Green Building Assessment Systems; source: E.P. Şimşek 2012, p.34

the use of green space, maintaining low CO^2 emissions and keeping environmental pollution low in construction activities, is a voluntary standard and is provided by the Green Building Council of America (USGBC). These ratings are performed in the following 6 categories with different scoring weights (Fig 3).

Fig. 3. LEED Credit Categories; source: www.clearwaterhomesutah.com/micah-peters-leeds-the-way-in-green-building-strategies-in-utah

Tab.1. Rating benchmarks

BREEAM 2011	% Points	LEED 2009	Points
Outstanding	≥85%	Platinum	≥80
Excellent	≥70%	Gold	60-79
Very Good	≥55%	Silver	50-59
Good	≥45%	Classified	40-49
Pass	≥30%	Unclassified	<40
Unclassified	<30%		

Source: data: M. Sleeuw 2011, p.7, prepared by the author

Fig. 4. A range of Certification;
source: www.clearwaterhomesutah.com/micah-peters-leeds-the-way-in-green-building-strategies-in-utah

LEED is a points-based system, and each building project earns LEED points to meet certain Green Building criteria. LEED Green Building rating system has 4 basic levels:

- LEED Certified, 40-49 points
- LEED Silver, 50-59 points
- LEED Gold, 60-79 points
- LEED Platinum, 80-+ points (Fig.4).

Under the six main categories given above, two design examples are evaluated. The reason for selecting these examples, both of these buildings, Konya Science Building and Singapore ArtScience Museum building, has LEED Gold Certified category and the same function. In this context, all related activities and strategies are described below.

3. COMPARING OF CERTIFIED GREEN BUILDINGS IN THE CONTEXT OF LEED CERTIFICATION CRITERIA

In order to make the correct comparison, two different examples of energy efficient design, one of them located in Turkey and the other one abroad, belonging to the same function and the same LEED certificate group are chosen as the sample area.

3.1. Konya Science Center in Turkey, Evaluation in terms of LEED Criteria

Konya Science Center project is implemented in Konya, which is the largest city in Asian part of Turkey and is the first and only Science Center in Turkey with LEED NC Gold certification (Fig.5). The construction process of the project is finished and it was inaugurated April 2014. The certification process also is deemed appropriate to be examined in terms of completion. Architectural Design A is owned by the project company and the project owner is Konya Metropolitan Municipality [N. Yanar 2015, p. 957].

The project realized with the support of Tübitak is located on a land area of approximately 100,000 m^2; 26.250 m^2 covered area, 14.000 m^2 open parking area and vehicle roads, 11.000 m^2 walkways, 47.000 m^2 green area. And besides, this building has thematic exhibits, outdoor exhibits, observation and cruising tower, planet house (Planetarium), lecture

Fig. 5. Location of Konya Science Center, 2014, general view, 2014; source: www.konya.bel.tr/haberbasin.php?haberID=4111&hDurum=FOTO

Fig. 6. Konya Science Center steel mesh shell system and geodetic shell; source: www.yenihaberden.com/bilim-merkezi-konyanin-markalarindan-biri-olacak-31967h.htm

Fig. 7. Use of green space on the land; photo by the author

halls, laboratories, and a library [E. B. Burkut 2018, p.1022,1023].

The main building is constructed with a steel mesh shell system of 110 meters in diameter and 30 meters in height. The planetarium building is built with a geodesic shell system approximately 24 meters in diameter, 12 meters in height [www.kamuprojeleri.com/yeni/Haber/HaberAyrinti.aspx?HaberId=10, Konya Bilim Merkezi Projesi Çelik Örgü Kabuk Çatısı], (Fig.6.).

Konya Science Center is a LEED Gold certified project developed by the American Green Buildings Council with 66 points awarded. Ecobuild undertook the consultancy service during the certification process. The decisions taken in terms of LEED categories for this building are listed below:

- **Sustainable sites**

Konya Science Center is positioned as environmentally sensitive in terms of the location selection. By selecting the Organized Industrial Zone as the building construction area, both green areas and fertile farmland are protected.

Public transportation (transportation by bus), bicycle parks and change rooms were tried in order to reduce to individual vehicle usage and thus prevent environmental pollution (CO^2 emissions) and fossil-based fuel usage. An intensive greening application has been carried out on an area of 47.000 m^2 (Fig.7), [N. Yanar 2015, p. 959].

Konya Science Center earned 22 points out of a possible 26 points as a result of measurement and evaluation in terms of sustainable sites (Tab.2).

Tab. 2. Konya Science Center, sustainable sites point.

SUSTAINABLE SITES		AWARDED: 22 / 26
SSc1	Site selection	1 / 1
SSc2	Development density and community connectivity	5 / 5
SSc3	Brownfield redevelopment	0 / 1
SSc4.1	Alternative transportation - public transportation access	6 / 6
SSc4.2	Alternative transportation - bicycle storage and changing rooms	1 / 1
SSc4.3	Alternative transportation - low-emitting and fuel-efficient vehicles	3 / 3
SSc4.4	Alternative transportation - parking capacity	2 / 2
SSc5.1	Site development - protect or restore habitat	1 / 1
SSc5.2	Site development - maximize open space	1 / 1
SSc6.1	Stormwater design - quantity control	0 / 1
SSc6.2	Stormwater design - quality control	0 / 1
SSc7.1	Heat island effect - nonroof	1 / 1
SSc7.2	Heat island effect - roof	1 / 1
SSc8	Light pollution reduction	0 / 1

Source: E. B. Burkut 2018, p.213

Fig. 8. Rainwater channel and high efficiency sensor battery; photo by the author

- **Water efficiency**

In the Konya Science Center, where rainwater management is conducted, roof rainwater is transferred in to two separate warehouses by using rain channels around the building and reused in the building. The building's water consuming equipment with reservoir is efficient (Fig. 8). Plants which are used in landscaping are selected because of the water-efficient plants that require a low level of water consumption.

This system saves more than 446,000 litres of water per year, with 53% less water consumption than normal equipment buildings. The Konya Science Center earned 10 total points as a result of measurement and evaluation in terms of water efficiency (Tab. 3).

- **Materials and resources**

Within the context of the protection of resources and the environment, recycled materials are collected and construction wastes are evaluated in accordance with the construction waste management plan. The building is documented to have recycled structural steel and concrete contents with 45% of the total of its materials. 100% of building structural materials are manufactured and local to Turkey. Thus, fuel consumption and environmental pollution caused by material transportation are minimized. The use of local materials can be characterized as an advantage considering that it is an input to the country's economy. 75% of solid waste is collected and recycled.

In order to prevent the heat island effect generated by the sun's rays on the roof of the building, 90% of the solar radiation reflecting material is used in the roof and exterior areas of Konya Science Center (Fig. 9). The building's greenhouse gas emissions are 39% less than other buildings.

The Konya Science Center earned 5 points out of 14 points available as a result of the measurement and evaluation in terms of material and resources (Tab. 4).

Fig. 9. Facade material that reflects the sun's rays by 90 % and using steel materials; source: photo by the author; http://ogm.meb.gov.tr/www/konya-bilim-merkezinde-fen-liseleri-matematik-zumre-baskanlarina-yonelik-uygulamali-egitim-programlari-basliyor/icerik/775

Tab. 3. Konya Science Center, water efficiency point.

WATER EFFICIENCY		AWARDED: 10 / 10
WEc1	Water efficient landscaping	4 / 4
WEc2	Innovative wastewater technologies	2 / 2
WEc3	Water use reduction	4 / 4

Source: E. B. Burkut 2018, p.213

Tab. 4. Konya Science Center, material and resources point.

MATERIAL & RESOURCES		AWARDED: 5 / 14
MRc1.1	Building reuse - maintain existing walls, floors and roof	0 / 3
MRc1.2	Building reuse - maintain interior nonstructural elements	0 / 1
MRc2	Construction waste Mgmt	0 / 2
MRc3	Materials reuse	0 / 2
MRc4	Recycled content	2 / 2
MRc5	Regional materials	2 / 2
MRc6	Rapidly renewable materials	1 / 1
MRc7	Certified wood	0 / 1

Source E. B. Burkut 2018, p.213

- **Energy and atmosphere**

As a result of measurement thermal comfort assessment, mechanical renewable energy systems, building shell performance calculation, this building gained 5 points out of a possible 35 points (Tab.5).

- **Indoor environmental quality**

The Konya Science Center provides 30% better quality air than other buildings according to ASHRAE 62.1 norms. Thermal comfort is designed according to ASHRAE 55 standards and it is a higher level compared to other buildings. Considering the sensitivity of human and environmental health, no carcinogenic building materials are used in the buildings. All adhesive, sealant and paint are used with low VOC (Volatile organic Component) amount (Tab.6).

- **Innovation in operations and regional priority**

The Konya Science Center meets Turkey's green building priorities. The building received extra points in areas where it performs more than threshold values [N. Yanar 2015, p.961]. When examined in terms of innovation in Operations and Regional Priority criteria, the building received a score of 5 points out of a possible 6 points (Tab. 7).

Tab. 5. Konya Science Center, energy and atmosphere point.

ENERGY & ATMOSPHERE		AWARDED: 18 / 35
EAc1	Optimize energy performance	15 / 19
EAc2	On-site renewable energy	0 / 7
EAc3	Enhanced commissioning	0 / 2
EAc4	Enhanced refrigerant Mgmt	2 / 2
EAc5	Measurement and verification	1 / 3
EAc6	Green power	0 / 2

Source: E. B. Burkut 2018, p.213

Tab. 6. Konya Science Center, indoor environmental quality point.

INDOOR ENVIRONMENTAL QUALITY		AWARDED: 4 / 15
EQc1	Outdoor air delivery monitoring	0 / 1
EQc2	Increased ventilation	0 / 1
EQc3.1	Construction IAQ Mgmt plan - during construction	1 / 1
EQc3.2	Construction IAQ Mgmt plan - before occupancy	1 / 1
EQc4.1	Low-emitting materials - adhesives and sealants	1 / 1
EQc4.2	Low-emitting materials - paints and coatings	1 / 1
EQc4.3	Low-emitting materials - flooring systems	0 / 1
EQc4.4	Low-emitting materials - composite wood and agrifiber products	0 / 1
EQc5	Indoor chemical and pollutant source control	0 / 1
EQc6.1	Controllability of systems - lighting	0 / 1
EQc6.2	Controllability of systems - thermal comfort	0 / 1
EQc7.1	Thermal comfort - design	0 / 1
EQc7.2	Thermal comfort - verification	0 / 1
EQc8.1	Daylight and views - daylight	0 / 1
EQc8.2	Daylight and views - views	0 / 1

Source: E.B. Burkut 2018, p.213

Tab. 7. Konya Science Center, innovation in operations and regional priority quality point.

INNOVATION		AWARDED: 5 / 6
IDc1	Innovation in design	4 / 5
IDc2	LEED Accredited Professional	1 / 1

REGIONAL PRIORITY		AWARDED: 2 / 4
EAc1	Optimize energy performance	1 / 1
EQc7.2	Thermal comfort - verification	0 / 1
SSc7.2	Heat island effect - roof	1 / 1

Source: E.B. Burkut 2018, p.213

3.2. ArtScience Museum in Singapore. Evaluation in terms of LEED Criteria

The innovative lotus-shaped ArtScience Museum is created by architect Moshe Safdie and transformed the art into the overall design of the building with sustainability. The main sustainable features of the museum include the uninterrupted integration of a rainwater collection system into the building, as well as the natural daylight that illuminates the museum's interiors [N. Tan et al. 2014, p.1-3]. The ArtScience Museum secured the prestigious LEED Gold certification under the existing buildings, called Marina Bay Sands Hotels. Also, this building is the first museum in Asia Pacific to obtain the globally recognized sustainability achievement [www.3blmedia.com/News/ArtScience-Museum-Marina-Bay-Sands-Retains-Prestigious-LEEDr-Gold-Certification], (Fig.10).

Fig. 10. ArtScience Museum in Singapore, 2011, views; source: www.marinabaysands.com/company-information/directions-to-marina-bay-sands.html, https://thehoneycombers.com/singapore/artscience-museum-singapore-late-night-things-to-do-in-march/

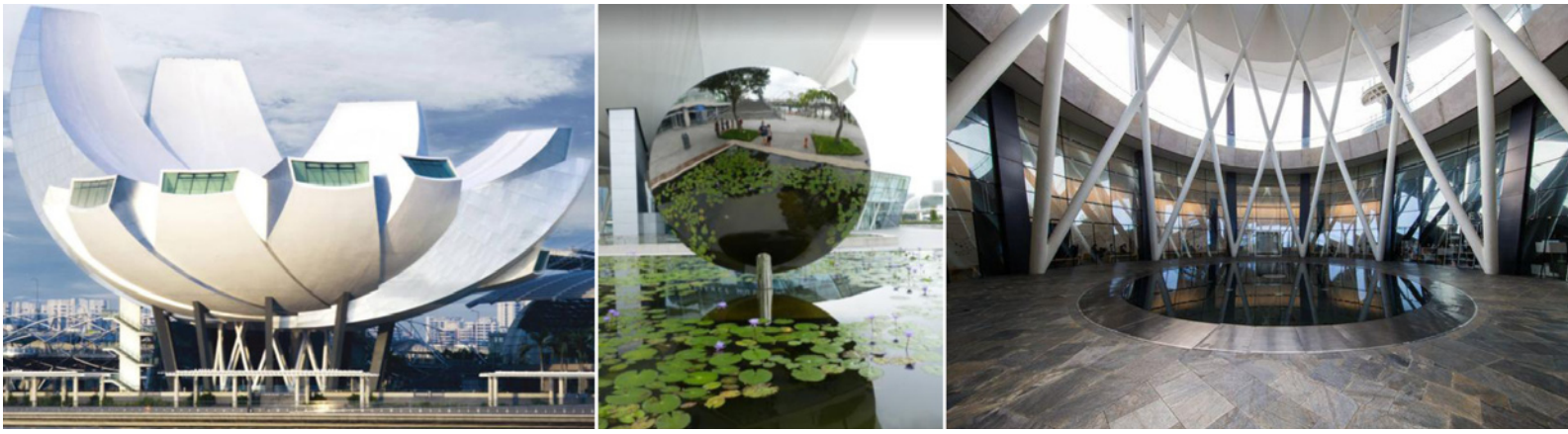


Fig. 11. A flower-like structure made of 10 petals and water element; source: Url: 11, https://thepeakmagazine.com.sg/lifestyle/artscience-museum-facts/?slide=4-4--It-has-a-Rain-Oculus-and-recycles-rainwater---W.

The design of the museum is composed of two principle parts. The base, which is embedded in the earth and surrounded by the Bay's water and a giant lily pond, and a flower-like structure made of 10 petals, generated by the geometry of spheroids of varying radii that seemingly floats above the landscaped pond base. The petals or fingers as some refer to them, rise towards the sky with varying heights, each crowned by a skylight which draws in daylight penetrating the base and illuminating the galleries within https://www.archdaily.com/119076/artscience-museum-in-singapore-safdie-architects, (Fig. 11). The museum is entered through a free-standing glass pavilion. Large elevators and escalators convey the public to the lower and upper galleries. In total, there are three levels of galleries with a total area of 6,000 square meters [www.area-arch.it/en/artscience-museum/].

As a museum that explores the intersection of art, science, technology and culture, ArtScience Museum is also home to the wild. This virtual reality experience welcomes visitors into a lush digital world of Southeast Asian rainforests, where pangolins, tapirs, tigers inhabit, encouraging visitors to take action to help preserve natural wildlife and plants through planting of a virtual tree [www.3blmedia.com/News/ArtScience-Museum-Marina-Bay-Sands-Retains-Prestigious-LEEDr-Gold-Certification], (Fig. 12).

The following are the decisions taken in terms of the LEED categories of the museum which has LEED NC Gold certification with 77 points.

- **Sustainable sites**

ArtScience Museum is located within the integrated resort of Marina Bay Sands, which has a luxury hotel concept, in the Downtown Core of the central area

Fig. 12. Natural wildlife and plants through planting of a virtual tree; source: www.marinabaysands.com/museum/future-world.html, https://archive.adcn.nl/archives/artscience-museum-into-the-wild

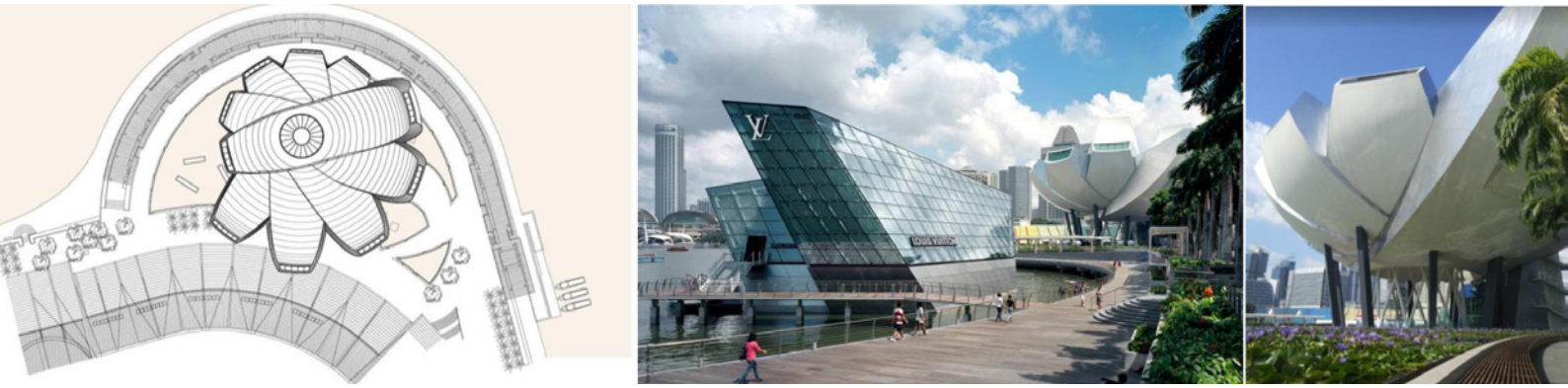


Fig. 13. The location of the building on the land and the use of green space; source: https://archello.com/project/the-artscience-museum-at-marina-bay-sands

in Singapore. It is located in the corner parcel overlooking the ocean and close to the bridges which connect the city. The hotel's facilities are available to prevent CO^2 emissions and fossil-based fuel use through individual vehicle use. A 75% reduction in conventional commuting trips is shown [www.gbig.org/activities/leed-100006652]. Besides, it is very important in terms of the perception of local and foreign visitors who come to the hotel. The use of green space and water elements in the land is achieved (Fig. 13).

The ArtScience Museum was awarded 21 points out of a possible 26 points as a result of measurement and evaluation in terms of sustainable sites (Tab. 8).

- **Water efficiency**

Key sustainable features of the museum include natural daylight illuminating the interiors of the museum, as well as the seamless integration of a rainwater harvesting system into the building. Featuring ten petals, each housing different gallery spaces, the building fea-

Tab. 8. ArtScience Museum, sustainable sites point.

SUSTAINABLE SITES		AWARDED: 21 / 26
SSc1	LEED certified design and construction	0 / 4
SSc2	Building exterior and hardscape Mgmt plan	1 / 1
SSc3	Integrated pest Mgmt, erosion control, and landscape Mgmt plan	0 / 1
SSc4	Alternative commuting transportation	15 / 15
SSc5	Site development - protect or restore open habitat	1 / 1
SSc6	Stormwater quantity control	1 / 1
SSc7.1	Heat island effect - nonroof	1 / 1
SSc7.2	Heat island effect - roof	1 / 1
SSc8	Light pollution reduction	1 / 1

Source: www.usgbc.org/projects/marina-bay-sands-artscience-museum

Fig. 14. The dish-like roof form collects rainwater; source: https://artthescience.com/blog/2016/01/19/spaces-artscience-museum/, https://archello.com/project/the-artscience-museum-at-marina-bay-sands

Tab. 9. ArtScience Museum, water efficiency point

WATER EFFICIENCY		AWARDED: 12 / 14
WEp1	Minimum indoor plumbing fixture and fitting efficiency	REQUIRED
WEc1	Water performance measurement	2 / 2
WEc2	Additional indoor plumbing fixture and fitting efficiency	5 / 5
WEc3	Water efficient landscaping	5 / 5
WEc4	Cooling tower water Mgmt	0 / 2

source: www.usgbc.org/projects/marina-bay-sands-artscience-museum

tures purposeful design to embody the natural world within a manufactured landscape. Each gallery is lit with natural skylights, and when it rains, the roof's unique shape channels rainwater through a central atrium to create a 35 meters waterfall at the building's centre. Water drained from the central pool is also recycled for use in the building [N. Tan et al. 2014, p.1-3]. The dish-like roof form collects rainwater and drains it through an oculus, creating a waterfall through the center of the museum that feeds an interior pond [N. Tan and friend 2014, p.1-3] efficiency achieved through the museum's Rain Oculus feature, where nearly 1,400,000 liters of rainwater is recycled each year. The water is reused for landscaping, water feature maintenance and toilets. This results in a 30% reduction in indoor potable water use (Fig. 14), [www.marketwatch.com/press-release/the-artscience-museum-at-marina-bay-sands-retains-the-prestigious-leedr-gold-certification-2018-11-28].

The ArtScience Museum is entitled to 12 points out of available 14 points as a result of measurement and evaluation in terms of water efficiency (Tab. 9).

- **Materials and resources**

The museum's envelope is composed of double-curved fiber reinforced polymer skin typically used at such a scale in the construction of boats and yachts. The vertical sides of each petal are sheathed in bead-blasted stainless steel panels. The unprecedented use of FRP is made possible the joint-less, continuous skin for each of the sail-like surfaces achieving a sense of lightness with their gleaming petals (Fig. 15). As elsewhere in Marina Bay Sands Hotel, the building aims

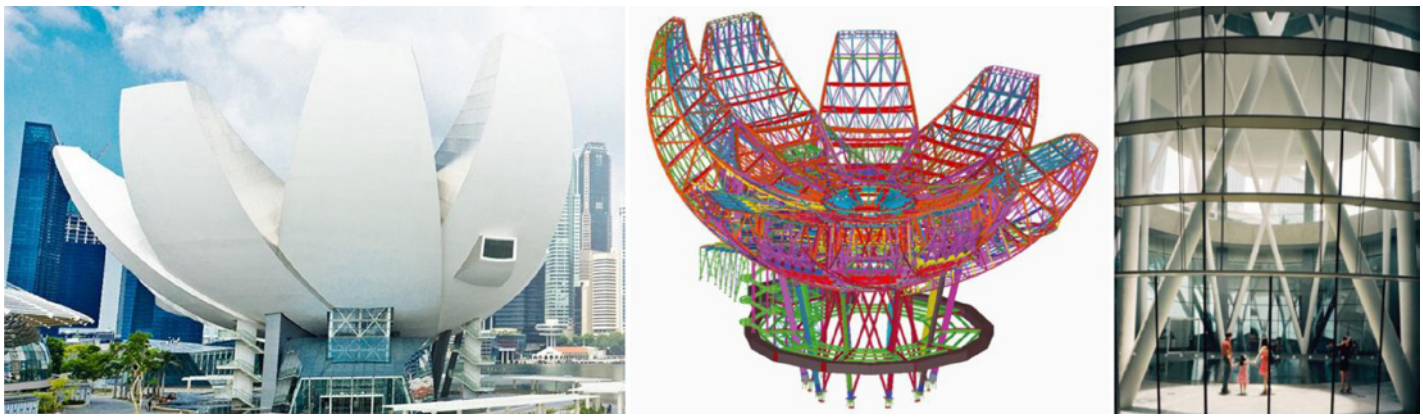


Fig. 15. ArtScience Museum, using steels and composed materials; source: https://archello.com/project/the-artscience-museum-at-marina-bay-sands, www.tekla.com/sg/references/artscience-museum

Tab. 10. ArtScience Museum, material vs resources point.

MATERIAL & RESOURCES		CONTINUED
MRc7	Solid waste Mgmt - ongoing consumables	1 / 1
MRc8	Solid waste Mgmt - durable goods	1 / 1
MRc9	Solid waste Mgmt - facility alterations and additions	0 / 1

Source: www.usgbc.org/projects/marina-bay-sands-artscience-museum

and achieves the highest levels of sustainability [https://archello.com/project/the-artscience-museum-at-marina-bay-sands].

The building meets the following factors in terms of the sustainability:

- 60% sustainable purchasing of ongoing consumables;
- 50% reuse, recycle or compost of ongoing consumables;
- 75% reuse or recycle of durable goods;
- a rigorous waste management strategy, which resulted in over 50 percent of all operational waste - such as paper, cardboard and plastics - is recycled;
- more than 50 percent of the museum's office and cleaning supplies are certified sustainable [www.3blmedia.com/News/ArtScience-Museum-Marina-Bay-Sands-Retains-Prestigious-LEEDr-Gold-Certification];
- the ArtScience Museum is entitled to 1 total score as a result of measurement and evaluation from the point of view of material and resources (Tab. 10).

- **Energy and atmosphere**

As a design concept, the „Lotus-Shaped" Singapore Museum collects light and rain (Fig. 16). Energy saving initiatives such as the use of LED lights and a programmable lighting system, which enables the museum to be 47 percent more energy efficient than similar rated [www.marketwatch.com/press-release/the-artscience-museum-at-marina-bay-sands-retains-the-prestigious-leedr-gold-certification-2018-11-28]. The building meets the following factors in terms of energy saving:

- 77 Energy Star Performance Rating;
- 6% or 50% onsite renewable energy or offsite renewable energy.

The ArtScience Museum is earned 16 points out of possible 35 points as a result of measurement and evaluation in terms of energy and atmosphere (Tab. 11).

- **Indoor envronmental quality**

The building meets the following factors in terms of the indoor environmental quality:

- 40% sustainable purchasing of electric equipment;

Fig. 16. ArtScience Museum, collecting sun and rain water with design concept; source: https://inhabitat.com/lotus-shaped-singapore-artmuseum-collects-rain-and-light/

Tab. 11. ArtScience Museum, energy and atmosphere point.

ENERGY & ATMOSPHERE		AWARDED: 16 / 35
EAp1	Energy efficiency best Mgmt practices -	REQUIRED
EAp2	Minimum energy efficiency performance	REQUIRED
EAp3	Fundamental refrigerant Mgmt	REQUIRED
EAc1	Optimize energy efficiency performance	6 / 18
EAc2.1	Existing building commissioning - investigation and analysis	2 / 2
EAc2.2	Existing building commissioning - implementation	2 / 2
EAc2.3	Existing building commissioning - ongoing commissioning	2 / 2
EAc3.1	Performance measurement - building automation system	0 / 1
EAc3.2	Performance measurement - system-level metering	0 / 2
EAc4	On-site and off-site renewable energy	3 / 6
EAc5	Enhanced refrigerant Mgmt	0 / 1
EAc6	Emissions reduction reporting	1 / 1

Source: www.usgbc.org/projects/marina-bay-sands-artscience-museum

Tab. 12. ArtScience Museum, indoor environmental quality point.

INDOOR ENVIRONMENTAL QUALITY		AWARDED: 10 / 15
EQp1	Minimum IAQ performance	REQUIRED
EQp2	Environmental Tobacco Smoke (ETS) control	REQUIRED
EQp3	Green cleaning policy	REQUIRED
EQc1.1	IAQ best Mgmt practices - IAQ Mgmt program	1 / 1
EQc1.2	IAQ best Mgmt practices - outdoor air delivery monitoring	0 / 1
EQc1.3	IAQ best Mgmt practices - increased ventilation	0 / 1
EQc1.4	IAQ best Mgmt practices - reduce particulates in air distribution	1 / 1
EQc1.5	IAQ best Mgmt practices - IAQ Mgmt for facility additions and alterations	1 / 1
EQc2.1	Occupant comfort - occupant survey	1 / 1
EQc2.2	Controllability of systems - lighting	1 / 1
EQc2.3	Occupant comfort - thermal comfort monitoring	1 / 1
EQc2.4	Daylight and views	0 / 1
EQc3.1	Green cleaning - high performance green cleaning program	1 / 1
EQc3.2	Green cleaning - custodial effectiveness assessment	1 / 1
EQc3.3	Green cleaning - purchase of sustainable cleaning products and materials	1 / 1
EQc3.4	Green cleaning - sustainable cleaning equipment	1 / 1
EQc3.5	Green cleaning - indoor chemical and pollutant source control	0 / 1
EQc3.6	Green cleaning - indoor integrated pest Mgmt	0 / 1

Source: www.usgbc.org/projects/marina-bay-sands-artscience-museum

– 40% sustainable purchasing of furniture;
– 25% sustainable food and beverage purchasing;
– 90% sustainable purchasing of reduced mercury lamps.

The ArtScience Museum is entitled to 10 points out of an available 15 points as a result of measurement and evaluation in terms of indoor environmental quality (Tab. 12).

- **Innovation in operations and regional priority**

The overall form of the ArtScience Museum is compared to a lotus flower and is dubbed, "The welcoming hand of Singapore" by Sheldon Adelson, chairman of Las Vegas Sands Corporation which developed Marina Bay Sands Hotels (Fig. 17). The ArtScience Museum is the first museum in the region to receive this award in reducing environmental impact and also the first LEED certificated museum building in Asia Pacific region.

The ArtScience Museum is entitled to 6 total points as a result of measurement and evaluation in terms of innovation in operations and regional priority (Tab. 13).

Tab. 13. ArtScience Museum, innovation in operations and regional priority point.

INNOVATION		AWARDED: 6 / 6
IOc1	Innovation in operations	4 / 4
IOc2	LEED Accredited Professional	1 / 1
IOc3	Documenting sustainable building cost impacts	1 / 1
REGIONAL PRIORITY		**AWARDED: 4 / 4**
EAc1	Optimize energy efficiency performance	0 / 1
EAc3.1	Performance measurement - building automation system	0 / 1
EAc3.2	Performance measurement - system-level metering	1 / 1
WEc1	Water performance measurement	1 / 1
WEc2	Additional indoor plumbing fixture and fitting efficiency	1 / 1
WEc3	Water efficient landscaping	1 / 1
INTEGRATIVE PROCESS CREDITS		**AWARDED: 0 / 2**
IPpc89	Social equity within the community	REQUIRED
IPpc90	Social equity within the operations and maintenance staff	REQUIRED

Source: www.usgbc.org/projects/marina-bay-sands-artscience-museum

CONCLUSION

Sustainable architecture has become an important concept in this period in which we seek solutions in order to compensate for the damage caused to the environment, to produce environmentally friendly buildings and even to improve existing building stock. Although international Green Building certification systems are accepted widely in the world, they have started to be demanded in Turkey recently. The number of green certified buildings are increased day by day in Turkey.

The case studies of this study are science center buildings, which have an important place in terms of bringing together science with society. These buildings from around the world and from Turkey are examined in the context of LEED criteria.

The study is carried out at the Konya Science Center, one of the science centers in Turkey. The Konya Science Center is the first and only LEED NC Gold certified science center in Turkey. It has an important mission in terms of being the first science center supported by TUBITAK (The Scientific and Technological Research Council of Turkey). The spaces colour design and lighting designs affect visitors and children. Also, it has been awarded LEED-Gold certificate with 66 points for its environmentally sensitive design, uses water efficiently, is environmentally sensitive, recycles waste and minimizes waste, takes care in the use of materials and resources.

However, when compared to the Singapore ArtScience Museum, it appears that it was not as awarded a design concept when it received the LEED certificate. Only, the building reached the score required by the LEED criteria with integrated mechanical renewable energy systems and tools (Tab. 14).

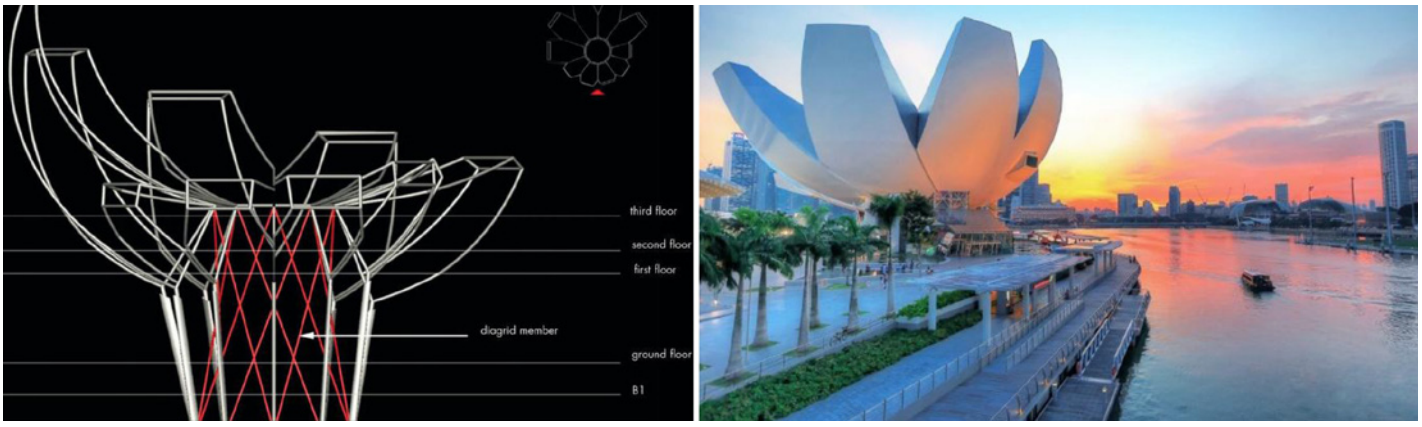
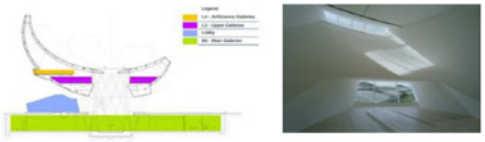
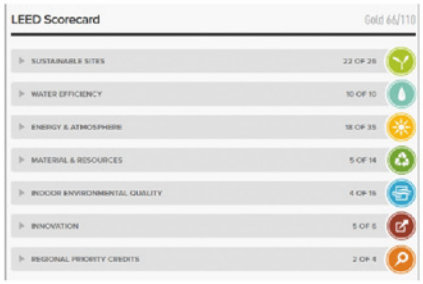


Fig. 17. ArtScience Museum, "The welcoming hand of Singapore" shape; source: Url: 7, www.visitsingapore.com/see-do-singapore/arts/museums-galleries/artscience-museum/

Tab 14. Comparing of certified example buildings in the context of LEED certification

LEED Criteria	Konya Science Center, Turkey	Artscience Museum, Malezya
Sustainable Sites	 By selecting the Organized Industrial Zone, both green areas and fertile farmland are protected. - 22 point	 Located within the integrated resort of Marina Bay Sands hotels - 21 point
Water Efficiency	 Rain channels and water consuming saving equipment with pressurized and unpressurized reservoirs - 10 point	 As a design consept, "Lotus-Shaped" Singapore Museum collects rain - 12 point
Materials and Resources	 -The use of recycled steel and concrete - Use of materials that reflect 90% solar radiation in all areas except the roof - 5 point	 - Double-curved Fiber Reinforced Polymer skin typically used - Blasted stainless steel panels continuous skin for each of the sail-like surfaces achieving a sense of lightness with their gleaming petals - 12 point
Energy and Atmosphere	 Mechanical renewable energy systems - 18 point	 Lotus-Shaped Singapore Museum collects light - 16 point
Indoor Environmental Quality	- Thermal comfort designed according to ASHRAE 55 standards - No carcinogenic building materials have been used - 4 point	40% sustainable purchasing of electric equipment 40% sustainable purchasing of furniture 25% sustainable food and beverage purchasing 90% sustainable purchasing of reduced mercury lamps - 10 point
Innovation in Operations and Regional Priority	 Turkey's first and only Leed Gold certified Science Center - 5 point	 The first LEED certificated museum building in Asia Pacific Region - 6 point
LEED Certificate Point	 66 point	 77 point

Source: prepared by the author; sources of pictures as of the previous pictures

For prestige and publicity purposes, a design is thought to have taken place in the name of obtaining a LEED certificate. In terms of its distance from the city center, it does not receive many visitors, it remains generally dormant. This building which is financially challenged should carry out activities for attracting to attract people and develop new functions in order to prevent dead investment. However, the Konya Science Center is an important example both in terms of being a public building and in terms that the Konya Metropolitan Municipality owns the Project. Also, it leads the market in terms of applications.

Although the Singapore ArtScience Museum has a LEED certificate (GOLD) of 77 points, it is on its way to being an energy efficient green building as a design concept. The building shell is shaped in order to collect rain water and sunlight. An effect is created that integrates science and people and takes on the role of the Science Museum in modern culture. The aim of the study is to contribute to the other studies interested in science centers.

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