Jernej Markelj, Manja Kitek Kuzman, Martina Zbašnik-Senegačnik

AR

UDK 721 : 657.92
COBISS 1.02
prejeto 11.7.2013

A REVIEW OF BUILDING SUSTAINABILITY ASSESSMENT METHODS

PREGLED METOD VREDNOTENJA STAVB PO NAČELIH TRAJNOSTNE GRADNJE

izvleček

Metode vrednotenja stavb po načelih trajnostnega gradnje so v svetu v uporabi že več kot dve desetletji. Njihova uporaba se je sprva le počasi širila po večjih razvitih državah, v zadnjih letih pa poteka nagel razvoj novih, regionalno prilagojenih orodij. Metode vrednotenja stavb so se razvijale na osnovi lokalnih značilnosti in zakonodaje, zato je njihova širša uporaba omejena. V članku so preučene najbolj znane mednarodne metode vrednotenja stavb BREEAM, LEED, DGNB in SBTool. S pomočjo vsebinske analize smo preučili njihov namen, potek in ceno vrednotenja, število certificiranih projektov, različice in vidike vrednotenja ter končno oceno. Rezultat je medsebojna primerjava posameznih metod. V diskusiji smo podali predvidevanja za nadaljnji razvoj metod vrednotenja stavb po načelih trajnostnega razvoja ter v sklepnem delu pregledali stanje in možnosti za vpeljavo metod v Sloveniji.

ključne besede

metode vrednotenja stavb, trajnostna stavba, BREEAM, LEED, DGNB, SBTool

abstract

Building sustainability assessment methods have been globally in use for more than two decades. Their use initially spread slowly through the larger developed countries, but in recent years we are seeing a rapid development of new, regionally adapted methods. The use of building assessment methods is limited because they developed on the basis of national legislation and local characteristics. In this article, the most important international building sustainability assessment methods BREEAM, LEED, DGNB and SBTool are investigated. With the help of content analysis we closely examine the aim, course and cost of the assessment, the number of certified projects, different assessment schemes, aspects of evaluation and the final certificate presentation. The result is a mutual comparison of individual assessment methods. In the discussion we present some predictions for the further development of building sustainability assessment methods. In the final part we review the situation and the possibilities for the implementation of these methods in Slovenia.

key words

building assessment methods, sustainable building, green building, BREEAM, LEED, DGNB, SBTool

Introduction

The primary role of building sustainability assessment methods is to verify and present the building's characteristics with the use of selected and verifiable standards. A building is assessed on the basis of an extensive selection of criteria from various domains which try as best they can to keep to the goals and principles of sustainable development by taking into account environmental, economic and social aspects.

There are different reasons behind the development and use of these assessment methods. In the first place, there is the demand for a public and transparent recognition of the quality of projects showing good practise. As construction legislation only prescribes minimal demands, projects that surpass these legally prescribed standards and are therefore of a higher quality are not rewarded. With the use of building assessment methods it is possible to evaluate the actual quality of the project [König et al., 2010: 96]. The other reason in favour of building assessment is greater ecological awareness of investors and familiarity with the negative potential of buildings. In their complete life cycle, buildings have a large influence on the environment due to their use of raw materials, the creation of waste and emissions. Buildings use 40 % of total final energy in the EU for their functioning alone and also produce a similar portion of greenhouse gas emissions. Buildings use 30 % of raw material sources and 20 % of water. Buildings are responsible for the creation of 30 % of waste [Eurostat, 2012; Lowe & Ponce, 2008: 8]. There are an increasing number of warnings from scientists and experts concerning the reaching and surpassing of our planet's limits as a result of human activity (Rockstroem et al. 2009). The key problems connected with this are climate change, atmospheric aerosol loading, water use, the depletion of the ozone layer, chemical pollution and the loss of biodiversity. According to the Intergovernmental Panel on Climate Change (IPCC, 2007: 36-41), human activity and the emission of greenhouse gases since the industrial revolution are the most probable reasons for the acceleration of climate change and the appearance of extreme weather phenomena. The use of building assessment methods encourages a reduction in the negative effects of buildings on the environment and also has other advantages [Ebert et al., 2011: 24]:

- demands represent planning guidelines and help investors specify the desired building quality when the project is being tendered;
- the quality of living in the building is improved;
- the building incurs smaller expenses in its entire lifecycle;
- there is greater transparency in the planning process;
- the market value of the building is greater due to the proven quality;

- the quality of different buildings can be compared on the basis of the final evaluation.

Comprehensive building assessment methods have been effectively in use abroad for over two decades while in Slovenia a practically useable method does not yet exist. The purpose of this article is to examine the current situation in the field of comprehensive building assessment globally and in Slovenia. We present the development of methods on a global level and undertake a comparison of the more recognised ones. We examine the situation and the possibilities for introducing and developing building assessment methods in Slovenia.

The development of different methods

The first widely used building assessment method is the BREEAM method, which was developed in 1990 in the UK. It focused above all on the assessment of the building's influence on the environment and the use of energy. It belongs to the methods of the first generation. The Green Building Challenge 98 also belongs to this group. It was the first attempt to develop a comprehensive assessment method from which the GBTool method later developed. Another important first generation method is the American LEED, which is globally the most widespread; then there is the Japanese CASBEE, the Australian GREEN STAR and the French HQE. A building assessed with the help of first generation methods is defined as a so-called green building.

Second generation assessment methods (LEnSE, DGNB), which have been developed in recent years, deal with the building in its entire lifecycle and also include economic, socio-cultural and technical aspects. With the inclusion of more aspects in the process of assessment the building is defined as a so-called sustainable building (fig. 1).

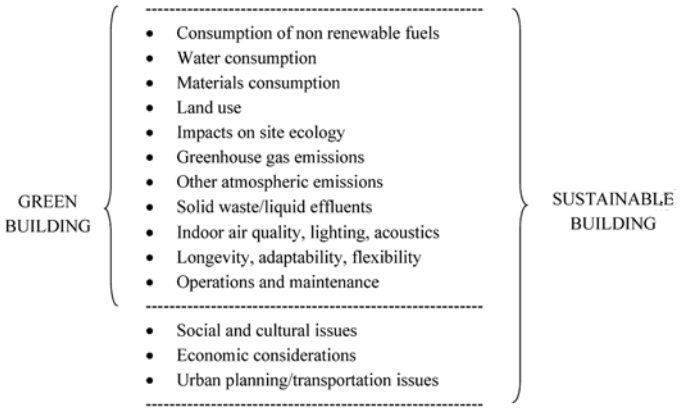

Figure 1: Aspects of assessment in first generation green building methods and in second generation sustainable building methods [Lowe & Ponce, 2008:11].
Slika 1: Vidiki vrednotenja pri metodah prve generacije za zeleno stavbo in pri metodah druge generacije za trajnostno stavbo [Lowe & Ponce, 2008:11].

Most building assessment methods are based on already existing methods, which have been upgraded or adapted to the circumstances and regulations in individual countries. Methods are adapted to the countries in which they have been developed as they follow national legislation, climate conditions, level of development and the economic status as well as other characteristics. There are large differences between them so the use of a method outside its home country is usually limited [Cole, 2010: 125].

In order to help understand the way building assessment methods have developed, we have presented an overview of the current situation in the form of a table (fig 2). The methods that have been developed on the same basis are marked with the same pattern. On the left-hand side is written the name of the country in which the building assessment method was developed and is in use. The coloured bands feature the name of the method with the date on which it was first used and the years in which the methods underwent important updates. For some methods, the names of countries in which the basic method was adapted for use in the assessment of buildings are listed under the band.

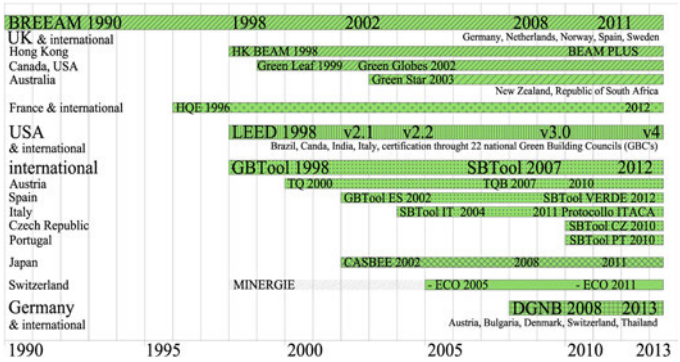

Figure 2: Table showing the development of building sustainability assessment methods.
Slika 2: Preglednica razvoja metod vrednotenja trajnostnih stavb.

During the building assessment process, individual criteria are given points, thereby producing a comprehensive final score that is simple to understand. On the basis of the final score, the building is classified in a certain class of demands that have been met and it is given a simple and recognisable certificate: e.g. a golden sign. The final presentation of the assessment result is important from the point of view of the building's promotion for the investors, as a quality guarantee for customers or users, for verification of the fulfilment of assessment demands for researchers and planners, as well as for determining the value of the property [Lützkendorf et al., 2011]. The use of assessment methods and certification of a building is usually done on a voluntary basis. In some countries, buildings that have been publically financed must be certified. In Germany, a method has been developed whose purpose is to assess new public buildings and this has helped improve their quality.

The costs of assessing buildings are different depending on which method is used, but they depend more precisely on:

- the cost of registering and certifying the project which depends on the type and size of the project;
- the cost of hiring a certified assessor or advisor to carry out the assessment and possible further analyses necessary for assessment (LCA, LCC, environmental report, Blower door test etc.);
- additional investment costs due to the quality of construction which differs from the legally prescribed

standards in comparison to a conventional building (e.g. higher energy efficiency, more efficient built-in mechanical equipment etc.).

International standardisation

Due to the existence of various different building assessment methods and the use of different criteria, the International Organization for Standardization (ISO) and the European Committee for Standardisation (CEN) several years ago began the international standardization of the field. This involves preparing a common basis for methods of assessing sustainable buildings. In this way they will also define more clearly the concept of a sustainable building [Mateus & Bragança, 2011: 1964]. In the past few years they have prepared several standards in the field of building assessment and their influence on the environment:

- standards of the ISO/TC 207 group: Environmental management which define environmental management, environmental signs, LCA and guidelines for environmental assessment [SIST, 2013a];
- standards of the ISO/TC59/SC17 group: Sustainability in buildings and civil engineering works which deal with the assessment of buildings and construction works according to the principles of sustainable development [ISO, 2013] and
- some of the prepared standards of the group CCEN/TC 350 - Sustainability of construction works [SIST, 2013b]

Standardization in the field of building assessment has not been completed as not all of the aspects of assessment have been defined.

Research projects

The aspiration to unify the definitions of different indicators, which form criteria and prepare a common basis for the methods of building assessment was responsible for connections between the institutions, which developed the methods and the research institutions. As part of various EU research projects in the past few years, new methods are being developed, which would build on the experiences of the existing and already prepared international standards to present a common methodology for further development [Lützkendorf et al., 2011]. Some of the more significant projects include:

- the LEnSE project (completed in 2007), in which a second generation method for building assessment was developed;
- the Enerbuild project (completed in 2012), in which tools for measuring the energy efficiency of buildings and a method for building assessment in the Alps were developed;
- the SuPerBuildings project (completed in 2012), in which indicators for the assessment of buildings were chosen according to the principles of sustainable development;
- the Perfection project (to be completed in 2013), in which indicators were chosen which deal with the quality of the internal environment in buildings in a comprehensive way;
- the Open House project (to be completed in 2013), in which a common European method of building assessment is being developed which takes into consideration the latest know-how and international standards. After the Open House project is completed, all the cooperating partners (including the Building and Civil Engineering Institute ZRMK and the Construction Cluster of Slovenia) will have access to tools developed in the project.

The main building assessment methods

We will now take a closer look at four of the most recognised building assessment methods in the western world, i.e. BREEAM, LEED, DGNB and SBTool. The methods have numerous similarities but nevertheless differ in various respects. They differ in the way assessment is carried out and the way information is prepared, the legal obligation for certification, the criteria dealt with and their share in the final score, the cost of certification and the possibilities of assessing different building types and different planning stages. The most widespread method is LEED with over 13,000 certified buildings and it is followed by BREEAM with over 4,200 buildings. Over 180 buildings have been certified with the DGNB method, which is the youngest. Assessment costs are lowest for the BREEAM method and the highest for the DGNB method. The estimated assessment cost that is given is based on the analysis of the assessment of newly built commercial buildings sized 6,000 – 9,000 m2, so it is necessary to emphasise that these are different for every project and depend on the size of the building, its intended use and the complexity of the project etc. Table 1 shows the main characteristics of different tools. Further down we present the course and costs of assessment for each of the methods that are dealt with, as well as different versions of the method, aspects of assessment and the final score.

building assessment method	BREEAM	LEED	DGNB / BNB
introduced in	1990	1998	2008
country	United Kingdom (UK)	USA	Germany
preparation of information	project leader, client or authorised assessor	project leader, client or authorised assessor	project leader, client or authorised assessor
assessment performed by	authorised assessor	USGBC	authorised assessor
certifying body	BRE Global	USGBC	DGNB / BMVBS
form	voluntary	voluntary	voluntary / compulsory
no. of certified buildings	> 4,200	> 14,000	> 180
no. of pre-certified projects	/	/	> 230
no. of registered buildings	/	> 41,000	> 700
no. of certified / registered residential units	> 200,000 (certified) > 1,000,000 (registered)	> 21,000 (certified)	/
no. of certified / registered residential projects	> 15,000	> 8,100	/
assessment scale (points)	sufficient (≥ 30), good (≥ 45), very good (≥ 55), excellent (≥ 70), outstanding (≥ 85-110)	certified (≥ 40), silver sign (≥ 50), gold sign (≥ 60), platinum sign (≥ 80-110)	bronze seal (≥ 50), silver seal (≥ 65), gold seal (≥ 80-100)
categories and their share in the final score	management (12 %) health and wellbeing (15 %), energy (19 %), water (6 %), transport (8 %), materials (12.5 %), land use and ecology (10 %), pollution (10 %), innovation (+ 10 %)	location and transportation (16 %), sites (10 %), water efficiency (11 %), energy and atmosphere (33 %), materials and sources (13 %), indoor environmental quality (16 %), innovation (+ 6 %), regional priority (+ 4 %)	environmental quality (22.5 %), economic quality (22.5 %), socio-cultural and functional quality (22.5 %), technical quality (22.5 %), quality of the process (10 %), quality of the location (separate)
cost of certification and registration	ca 1,000 – 2,000 EUR	ca 2,500 – 21,000 EUR	ca. 3,000 – 25,000 EUR
total assessment costs	ca 5.4 EUR/m^2	ca. 6 EUR/m^2	ca. 10 EUR/m^2
pre-certificate	possibly	possibly	✓
new construction	✓	✓	✓
renovation	✓	✓	✓
in-use	✓	✓	✓

Table 1: A comparison of different building assessment methods [Sources: Moro 2011; König et al., 2010: 99; Reed et al., 2009; BRE Global, 2013a; DGNB, 2013; USGBC, 2013; Birgisdottir & Hansen, 2012].
Tabela 1: Preglednica metod vrednotenja stavb [Viri: Moro 2011; König et al., 2010: 99; Reed et al.; 2009, BRE Global; 2013a; DGNB, 2013; USGBC, 2013; Birgisdottir & Hansen, 2012].

BREEAM - Building Research Establishment's Environmental Assessment Method

The British BREEAM method is the oldest building assessment method. It was developed by the Building Research Establishment (BRE) and has been in use since 1990 [Kajikawa et al., 2011: 236]. The latest version of the method, which also takes into account the latest standards regarding the sustainability of buildings CEN/TC 350, is BREEAM 2011 [BRE Global, 2013a]. The BREEAM method served as the basis for the preparation of numerous other assessment methods that have now become quite widespread in the world [Fowler & Rauch, 2006: 3; Ebert et al.: 25]: HQE (France), LEED (ZDA), Green Globes (Canada), CEPAS, Green Star (Australia), HK BEAM (Hong Kong), Green Building Rating System (South Korea).

Assessment procedure

A building is assessed with the help of an independent authorised assessor. The investor can decide to assess the building while it is already in the planning stage or even after it has already been built. Assessment in the planning stage is more effective as the project can be improved in cooperation with the assessor but it only leads to an interim BREEAM certificate. In order to acquire the final certificate it is necessary to carry out the second part of the assessment after construction has been completed. In order to ensure as good a result as possible BRE Global proposes to include the assessor in as early a phase of the preparation of the project as possible – when the goals of the project are being defined.

Number of certified projects

Ever since the BREEAM method was first used, over 4,200 projects have been certified in Europe [Ciampa & Hartenberger, 2012: 3]. On the web register Greenbooklive [BRE Global, 2013b] it is possible to see a list of all the buildings that have been certified since 2008. It features over 3,700 certified projects. Globally, over 200,000 units in over 15,000 projects have been certified according to the BREEAM method, but this includes projects certified through the scheme BREEAM Eco-Homes (nowadays in use under the name Code for Sustainable Homes), which was ttaken over by the public authority and is compulsory for certifying social housing projects.

Assessment schemes

Different assessment schemes have been developed for the needs of assessing different types of building [BRE Global, 2013a]:

- new construction: a scheme for assessing new non-residential buildings;
- refurbishment: a scheme for assessing the renovation of a building;
- in-use: a scheme for assessing a building that is in use;
- eco-homes: scheme for certifying residential buildings;
- communities: scheme for assessing larger scale projects comprising a whole neighbourhood in the planning phase;
- adapted schemes: meant for the assessment of buildings outside of the UK (office and commercial buildings in Europe; buildings in the Gulf states;
- international agreement: a scheme that can be adapted for the assessment of projects anywhere in the world.

In cooperation with local partners they also developed local variants of the BREEAM building assessment method in the Netherlands, Norway, Sweden, Germany and Spain.

Assessment categories

The BREEAM method assesses the fulfilment of demands for almost fifty different criteria (BREEAM New Construction scheme), which are arranged in ten categories:

- management – the whole process of managing and also preparing the project;
- health and wellbeing – criteria connected with the domestic environment;
- energy – the efficient use of energy;
- transport – criteria connected with public transport and location;
- water – efficiency of water use;
- materials – influences on the environment of the building's materials throughout its lifecycle;
- waste – efficiency in the reduction of waste connected with energy use, materials and processes;
- health and wellbeing – influence on the environment, biotic diversity and degraded zones;
- pollution – factors connected with the pollution of air and water;
- innovation – the ability to find new solutions.

Final score

The final score is the sum of the credits attained in individual categories. Depending on the number of points attained, the building is ranked in one of the following quality groups: pass (30-44 points), good (45-54 points), very good (55-69 points), excellent (70-84 points) or outstanding (85-110 points). A building, which achieves a score of excellent or outstanding, can be considered to be an example for future planning and construction of new sustainable buildings and is therefore presented to the broader public. However, the end of the construction phase does not yet mean that the building will also be used in an efficient way with minimal effects on the environment. Every new building needs several years for the most efficient functioning of technical systems and the building's optimal manner of use to be determined. Due to the optimisation of the building's functioning and the spreading of know-how concerning sustainable construction, a building that has been graded excellent or outstanding must after three years of use again be assessed according to the scheme BREEAM In use, otherwise its grade is lowered by one level.

LEED - Leadership in Energy and Environmental Design

The LEED method for assessing green buildings is in use in the largest number of different countries. It was developed in 1998 by the U.S. Green Building Council (USGBC), which is responsible for it. It is used in its original form in the USA and Canada, and in an adapted form in Brazil, Argentina, Mexico, Italy and India. Through the intermediary of local associations for green building (Green Building Council - GBC) it is present in more than 20 countries in the world [Cole, 2010: 126; Augenbroe & Malkawi, 2009: 73].

Assessment procedure
Assessment is carried out by an independent, non-profit institute for the assessment of green buildings, the Green Building Certification Institute (GBCI). The involvement of an authorised LEED expert is not compulsory, but nevertheless secures an extra point. The role of the authorised expert is to advise the client in his planning and to help prepare evidence as part of the certification process. In the beginning it is necessary to choose a variant of the method according to which the project will be assessed and to register it. The completed forms are then submitted to the GBCI, which then carries out the assessment and issues the final certificate [Kajikawa et al., 2011: 237].

Number of certified projects
By July 2013 there were 54,300 projects in over 135 different countries that had been registered with the LEED method, and over 14,000 of them have been certified [USGBC, 2013].

Assessment schemes
The last valid version of the LEED method, v.4 (2013), contains 5 variants depending on the type of project and can be applied to specific types of building:

- building design and construction:
- interior design and construction;
- existing buildings: operations and maintenance;
- neighbourhood development;
- homes – detached houses and small apartment projects.

Assessment categories
The assessment criteria are set out in eight different categories.

- location and transportation – properties of the location, proximity of services and transport possibilities;
- sustainable sites – preservation of habitat and biotic diversity of the land;
- water efficiency – economical water use, the use of effective appliances and raising the awareness of users;
- energy and atmosphere – energy efficient use of appliances within the building, the building itself and its location, and the economical use of renewable energy sources;
- materials and resources – a selection of materials, their renewed use and waste;
- indoor environmental quality – air, light, sound and the possibility of operating with appliances;
- innovation – promotion of innovations, the surpassing of LEED demands and the involvement of an authorised LEED expert;
- regional priority – the fulfilment of demands that are specific to the region.

Final score
Depending on the number of points gained in relation to the criteria, the building is given a rating in one of the four quality classes: classified (40-49 points), silver (50-59 points), gold (60-79 points), platinum (80-110 points). Information concerning the rating can be acquired in the planning phase but the final assessment and presentation of the certificate is carried out only after construction is completed. If assessment is carried out according to the LEED New Construction: Core & Shell scheme, it is possible to acquire a preliminary certificate for the purpose of marketing the project while the building is still in its planning phase.

DGNB - Deutsches Gütesiegel Nachaltiges Bauen
Together with the Federal Ministry of Transport, Building and Urban Development (Bundesministerium für Verkehr, Bau und Stadtentwicklung - BMVBS) the German Sustainable Building Council (Deutsche Gesellschaft für Nachhaltiges Bauen - DGNB) has prepared a method of building assessment that was described in 2008, when it was presented, as a second generation assessment method. The method addresses the building's entire lifecycle and does not assess only the operational phase [König et al. 2010: 101; Eberl, 2010: 2]. The assessment method focuses on environmentally friendly and energy efficient buildings that help preserve natural resources and ensure a high level of well-being for its users. Two versions of the method are in use: the building assessment method DGNB (Deutsches Gütesiegel Nachaltiges Bauen) for general use and the method for assessing buildings that are owned by the state BNB (Bewertungssystem Nachhaltiges Bauen für Bundesgebäude). The method was developed for the German building sector so it is based primarily on German standards and technical directives. In 2010, the DGNB International scheme was prepared with the intention of making the trademark present internationally. This scheme complies with EU regulations and standards [Hardziewski & Wallbaum, 2011: 32]. With the help of local agencies it has been adapted for use in Austria, Switzerland, Bulgaria and China; they also cooperate with representatives in other countries. It is possible to have a building assessed in Slovenia according to the DGNB method through an authorised Slovenian assessor [Green Building Council Slovenia, 2013].

Assessment procedure
In order to have an assessment carried out, the client must hire an authorised DGNB assessor who will first register the building. Together with the client they first determine the goals of the project – this should take place as early on as possible in the planning phase due to the increased possibility of attaining a greater quality of building and a better final score in the assessment. In the planning phase it is possible, upon assessment, to acquire a preliminary certificate for the purposes of marketing the project. The final certificate is acquired after the building is completed and after a positive review of the demanded assessment documentation at DGNB [Eberl, 2010: 2].

Number of certified projects
In the register of certified DGNB buildings which is freely accessible on the DGNB website [DGNB, 2013], over 750 projects globally had been registered with the DGNB method by July 2013. Of these, 235 have a preliminary-certificate and 200 have the final certificate.

Assessment schemes
Ever since 2008, when they began with a scheme for assessing

newly built commercial and office buildings, the system was expanded and now also has other schemes [DGNB, 2013]:

- existing buildings: commercial and office buildings, retail buildings, industrial buildings, apartment buildings;
- new construction: commercial and office buildings, the refurbishment of commercial and office buildings, buildings meant to house educational activities, retail buildings, hotels, industrial buildings, hospitals, laboratories, buildings to be let out, apartment buildings (at least units), small apartment buildings (up to 6 units), buildings for large events;
- urban districts: greater build areas, industrial zones, commercial zones.

Assessment categories

In six assessment categories it covers aspects of sustainable building with 42 criteria [DGNB, 2013]:

- environmental quality – the effect of the building on the environment is assessed as part of its whole lifecycle. Testing for greenhouse gas emissions, the use of primary energy, water consumption, effects on the environment and the use of land;
- economic quality – is assessed on the basis of an analysis of the building's costs throughout its lifecycle (LCC analysis). Emphasis is on the reduction of the building's costs and on preserving the value of the property;
- socio-cultural and functional quality – involves the assessment of the effect on the well-being and health of the users, functional characteristics and the design quality of the project;
- technical quality – involves the assessment of the building's various technical characteristics: protection against fire and noise, quality of the building's shell, ease of cleaning and maintenance, the possibility of straightforward removal, recycling or depositing of parts of the building;
- quality of the process – it is the quality of the planning and construction processes that is assessed. The primary goal is the integration of standards of sustainability in as early a phase of planning as possible, and compliance with the principles of sustainable procurement and construction;
- quality of the location – assessment of access to public transport, the proximity of important buildings and supporting services, and the appearance of the neighbourhood in which the building is located. The quality of the location is assessed independently.

Final score

Depending on the final score achieved, a certificate or seal of sustainable building is given at three possible levels: bronze seal (over 50 %), silver seal (over 65 %) and a gold seal (over 80 %).

SBTool – Sustainable Building Tool / GBTool – Green Building Tool

The SBTool method for assessing sustainable buildings, the successor of the GBTool method for assessing green buildings, has been set up by an international non-profit organisation called International Initiative for a Sustainable Built Environment (iiSBE). The organisation, whose headquarters are in Canada, brings together experts and groups active in the field of sustainable building from more than 25 countries. It strives to create a forum for the exchange of information in the field of sustainable building and prevent the repetition of work that has already been done and the setting up of common assessment standards [iiSBE, 2013]. The method for building assessment they have developed has been in a state of constant development since 1996. In 2005, the method's name was changed from GBTool to SBTool, with which they wanted to emphasise the inclusion of social and economic aspects in assessment [Augenbroe & Malkawi 2009: 71]. In contrast to the other assessment methods, SBTool / GBTool was not meant for use on the market but above all for use by researchers in preparing local assessment methods and the development of the methodology of building assessment. In the Green Building Challenge competition researchers and national groups met generally once every two years and presented their adjustment of assessment methods to local circumstances and their application to projects. In this way they stimulated the exchange of know-how and experience in the field of developing methods of building assessment [Kajikawa et al., 2011: 238].

The method is devised in such a way that it can be adapted to regional conditions such as climate, materials and construction technology while retaining a common structure and assessment terminology which allows international comparison. In developing the latest version of the SBTool method in 2012 they complied with the international ISO and CEN standards that had already been issued in this field [iiSBE, 2013]. An adapted version of the method has been developed in recent years in a number of different countries: in Italy the Protocollo ITACA, in Spain SBTool VERDE, in the Czech Republic SBTool CZ and in Portugal the SBToolH PT method [Berardi, 2011], which shows that it is possible to adapt the method to the local situation.

Assessment schemes

The method can be used in different phases of the project [iiSBE, 2013]:

1. project preparation phase: evaluation and choice of the most suitable location;
2. the planning phase: the project is assessed on the basis of plans and documents;
3. building phase;
4. operational phase: assessment of building in operation, at least 2 years after its completion.

Assessment categories

The method contains over 100 defined criteria. The method also enables basic assessment with over 50 criteria and simplified assessment that takes into consideration only 15 key criteria. The scope of the assessment depends on size, how complex the building is and on individual decisions. The criteria are arranged in 8 categories:

- site regeneration and development, urban design and infrastructure – accessibility of services, regeneration of the building plot, urban design and infrastructure;
- energy and resource consumption – non-renewable energy sources, materials, water;

- environmental loadings – emissions of greenhouse gases, waste, effect on the creation of urban heat island;
- indoor environmental quality – air, lighting, sound;
- service quality – security, functionality, effectiveness and control over appliances;
- social, cultural and perceptual aspects – privacy, accessibility for physically handicapped persons, heritage;
- costs and economic aspects – costs of construction, operation, maintenance; accessibility to customers.

Final score

The number of points allocated to an individual indicator is based on a comparison of the building that is being treated and a conventional building in the local environment. In the event of a result that is lower than a conventional building, the score for an indicator is -1, if the values of the two buildings are similar then the score is 0, if the value is higher the building gains 3 points and if it is exemplary then it gains 5 points. Points gained for different indicators are added together in the proportions of the final score they make up. The quality ratings are defined on the basis of the final score.

Comparison of assessment methods

The result of the study is a comparison of selected building assessment methods. We wanted to prepare the analysis on the basis of the latest developments in this field. As a framework for comparison we therefore took the Open House method, which is being prepared by a number of international partners and which takes into consideration the latest results from the process of standardisation. As a second generation building assessment method it comprehensively assesses the building's effects throughout its lifecycle and covers all relevant fields of sustainability. The Open House method contains 6 categories:

- environmental aspect – effects on the environment, energy use, materials, waste and water use;
- social aspect – functional, cultural and design criteria, quality of the interior environment and effects on health;
- economic aspect – costs connected with the building throughout its lifecycle, the value of the property and the possibility of marketing;
- technical characteristics – protection against fire, the durability of the surfaces and maintenance, resistance to weather;
- process and management – procedures for planning, procurement, construction and the building's operation;
- location – the possibility of public transport, proximity of other services and the characteristics of the neighbourhood.

We compared the latest versions for assessing newly constructed buildings with different systems: BREEAM 2011 New Construction Offices, LEED v.4 Building design & Construction, DGNB New Office and administrative building 2012 and SBTool 2012 Medium Assessment. We placed the individual criteria for each method in the most relevant category according to the Open House project. In this way we were able to compare how much an individual category contributed to the final score (tab. 2).

category	BREEAM	LEED	DGNB	SBTool
environmental aspect	58.3 %	60.0 %	22.5 %	67.3 %
social aspect	21.5 %	17.0 %	22.5 %	23.6 %
economic aspect	1.6 %	0.0 %	22.5 %	1.9 %
technical characteristics	4.6 %	2.0 %	22.5 %	5.1 %
process and management	10.4 %	12.0 %	10 %	2.1 %
location	3.6 %	10.0 %	separate	separate
total	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**
additional points	+ 10.0 %	+ 10.0 %	/	/

Table 2: Comparison of the share of categories in the final score based on the Open House project.
Tabela 2: Primerjava deležev kategorij v končni oceni po projektu Open House.

In comparing the shares of different categories in the final score of the assessment it was found that despite the latest modifications there is still a noticeable difference between methods of the 1st and 2nd generation. BREEAM, LEED and SBTool put the greatest emphasis on environmental aspects - around 60 % of the final score. The economic and technical aspects have almost no influence on the final score. With DGNB, on the other hand, all the categories, except for process and management, are equally weighted and make up 22.5 % each. There is also a difference in the assessment of the location and additional points which are part of the final score in BREEAM and LEED, while in DGNB and SBTool the location is assessed separately and there are no additional points. For a clearer demonstration of the shares of points in different assessment categories we have prepared a graphical representation (fig. 3).

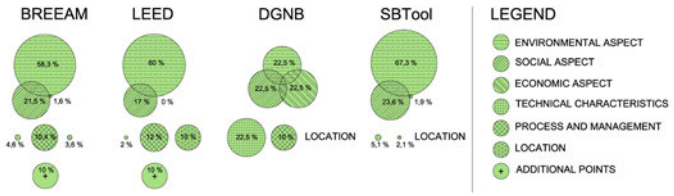

Figure 3: Graphical representation of the shares of individual categories in different building assessment methods.
Slika 3: Grafični prikaz deleža posameznih kategorij pri metodah vrednotenja stavb.

The analysis of the shares of individual categories does not yet tell us which criteria have been dealt with in individual categories so we have prepared another analysis to help better understand the similarities and differences between the assessment methods. We have based this analysis on the previous one on methods of building assessment [Ebert et al., 2011: 97], and have added to it the SBTool 2012 Medium Assessment method. We verified which criteria are dealt with during assessment and which are not (tab. 3).

We discovered that the DGNB method covers the largest stretch of criteria but does not include assessment from the point of view of preservation of biotic diversity, protection of the natural environment on the plot of land, some criteria connected with meters and electrical appliances and the direct rewarding of innovations. The LEED and BREEAM methods have deficiencies in the coverage of some economic, social, functional,

design and technical criteria. The propositions of the SBTool method cover a broader spectrum of aspects of the assessment of sustainable buildings than the LEED and BREEAM methods but nevertheless fail to include design criteria and the criteria of the processes of planning, construction and ordering.

categories	criteria	BREEAM	LEED	DGNB	SBTool
environmental aspect	strain on the environment / pollution	✓	✓	✓	✓
	materials / sources	✓	✓	✓	✓
	waste	✓	✓	✓	✓
	water	✓	✓	✓	✓
energy aspect	CO_2 emissions	✓	✓	✓	✓
	efficiency of energy use	✓	✓	✓	✓
	renewable energy sources	✓	✓	✓	✓
	energy efficiency of the building's outer layer	✓	✓	✓	✓
	technical equipment of the building		✓	✓	✓
	control over energy use	✓	✓	✓	✓
	intermediate counters and meters	✓	✓		
	equipment with electric appliances	✓	✓		✓
economic aspect	building's costs throughout its lifecycle	✓	✓	✓	✓
	preservation of the property's value			✓	
socio-cultural aspect	security and safety	✓	✓	✓	✓
	accessibility to physically handicapped persons	✓		✓	✓
	regional and social aspects	✓	✓	✓	✓
	possibility of control by user	✓	✓	✓	✓
functional aspect	effective use of space			✓	✓
	possibilities for rearrangement			✓	✓
design and innovation	architectural quality			✓	
	inclusion of art			✓	
	innovation	✓	✓		
technical aspect	fire safety			✓	
	quality of the exterior	✓		✓	✓
	cleaning and simplicity of maintenance			✓	
	resistance to the effects of weather			✓	✓
process	planning process	✓	✓	✓	
	course of construction work	✓	✓	✓	
	ordering	✓	✓	✓	
	operation	✓	✓	✓	✓
location	micro-location	✓	✓	✓	✓
	traffic connections	✓	✓	✓	✓
	comfort for cyclists	✓	✓	✓	✓
	neighbourhood	✓	✓	✓	✓
	possibility of extensions			✓	
	use of space	✓	✓	✓	
	protection of nature and the building plot	✓			✓
	biodiversity	✓	✓		✓

Table 3: A comparison of included criteria in BREEAM, LEED, DGNB and SBTool methods [extended and edited from Ebert et al., 2011: 97].
Tabela 3: Primerjava vključenosti kriterijev pri metodah BREEAM, LEED, DGNB in SBTool [dopolnjeno in prirejeno po Ebert et al., 2011: 97].

Discussion

Methods of building assessment are currently in a transitional phase. Most of the existing first generation systems will have to include additional aspects of sustainability, above all economic and technical criteria, as this is foreseen by emerging international standards [Lützkendorf et al., 2011]. Second generation methods are more demanding as assessment must include the Life-Cycle Assessment (LCA) and the Life-Cycle Cost Analysis (LCC). Usually this includes the phases of acquisition of raw materials, production of materials, construction and operation of the building during a period of around 50 years. This allows a more precise and reliable comparison than first generation methods. To create an analysis it is best to use local databases concerning materials and products; under certain conditions it is also possible to use foreign databases. Meanwhile, it is necessary to bear in mind that they contain information that has been prepared on the basis of local conditions from which the materials and products originate. However, these may differ depending on which country or region they come from. The best known databases in Europe are the Swiss Ecoinvent and the German Ökobau.dat and GaBi [König, 2011: 86]. In Slovenia we do not yet have a materials database [Šijanec Zavrl, 2010: 30]. The Slovenian National Building and Civil Engineering Institute has begun a project to prepare an Environmental Product Declaration (EPA), which will enable the use of LCA data for materials and products in Slovenia.

In some European countries, methods for assessing sustainable buildings have not yet been developed but the need for this is growing. Private investors are particularly keen for the development of such methods as the acquisition of a certificate makes it easier for them to market a property and prove that they are bound to the goals of sustainable development. In the context of public procurement, the state would also like to acquire projects that are of as high a quality as possible and to be an example to others in the field of sustainable building. The introduction of a building assessment method can take place in a number of different ways. Some countries are targeted by assessment methods that have a program of international expansion (e.g.: LEED, BREEAM, DGNB), and they are helped by local green building councils (GBC). In these cases individual demands in a method are adapted to local conditions. Some countries are developing their own building assessment methods by financing national research projects at universities and other research institutions. These assessment methods are mainly based on adapting the SBTool method or setting up a completely new method following the prior analysis of existing methods. This can lead to the creation of practically applicative methods (Portugal, the Czech Republic). The third way is being developed by international research projects, which aim to prepare a common framework for building assessment in a broader area (e.g. Open House, Enerbuild). These are also supposed to enable the adaptation of individual criteria and parts of different aspects to the final score, depending on the particularities of countries or regions. At the same time they are supposed to ensure that development partners possess all the other necessary tools and databases for the assessment. This would enable the continued development or use of a method in the local area after the research project is no longer being financed. It also occurs that in some countries (e.g. Austria, Italy, Bulgaria, Switzerland) a number of different international methods are in use because the local methods of comprehensive assessment have not been recognised or have not yet been developed. There have also been cases when the client has demanded a more sustainable building and so projects have been optimised and assessed with several methods.

In Slovenia it is possible to certify a building with internationally recognised tools (LEED, BREEAM, DGNB), however, this is not being done. There are a number of reasons for this. The majority of clients are not yet familiar with the field of sustainable construction and there is a lack of authorised experts that can carry out assessment according to an individual method. The greatest obstacle is verifying the criteria from different

methods as they are based on the regulations and laws of foreign countries.

Slovenia does not have its own comprehensive building assessment method. In 2006, the building and civil engineering institute ZRMK prepared the groundwork for the assessment of buildings containing apartments as part of a project entitled Mark of Quality in Construction, but due to the lack of financial means the project was not finished [Šijanec Zavrl et al. 2009; ZKG, 2012]. Another step in this direction is the recently adopted Green Public Procurement Order [ZeJN, 2012] and the building's "Energy performance certificate", however, these do not offer a comprehensive analysis of the building's quality. In the face of the challenge of how to improve the quality of buildings in Slovenia and the increased interest of investors for the assessment of buildings, it would be worth introducing a comprehensive building assessment to Slovenia. There are at least three possibilities for preparing a method for building assessment in Slovenia:

a) The development of a new building assessment method

As some other countries, which are comparable with Slovenia, have shown, it is possible to successfully develop a new building assessment method, which is based on already recognised models and is adapted to local conditions. It is crucial that we take into account the specific characteristic of the Slovenian environment while at the same time retaining common international indicators in the method. In some countries they have prepared their own methods by using the SBTool method as a guide. This has usually taken place within the framework of research or university institutions. The development of a new method is the most difficult task so in order for it to be done successfully a number of different experts would have to cooperate on the project and it should have suitable support from the state.

b) Further development of the Open House project

A good way of acquiring a building assessment method would be to continue to develop the Open House project, on which the Slovenian ZRMK and Construction Cluster of Slovenia are already cooperating. The method builds on existing assessment methods by respecting the latest international standards. This project also includes the development of supportive tools for assessment, which would facilitate the implementation of this method.

c) Use and adaptation of the DGNB method

In practise the DGNB method has proved to be of a good quality and has been well received. With the inclusion of the LCA and LCC analyses it makes use of the latest approaches in building assessment, is more precise than the other methods while at the same time being the most demanding and the most expensive to use. Unlike LEED and BREEAM, it covers the broadest spectrum of aspects of sustainable building and treats them on an equal basis. The DGNB method is also suitable for the Slovenian environment as it is based on DIN and EU standards, which means it can easily be adapted.

The choice of assessment method should be based on the expert opinions of different institutions and it would also make sense to include the legislator. For the successful implementation of assessment methods in the planning process it is also a recommended to have support and promotion from, for example, the Chamber of Architecture, the Chamber of Engineers and the Ministry of the Environment and Spatial Planning. It would be meaningful to integrate the prepared method into a system of public procurement as this would also give an example to the private sector.

Conclusion

Sustainable building assessment methods have shown how useful they are in creating new environmental paradigms [Conte & Monno, 2011]. With the help of clearly set out criteria of sustainable building they promote and lead to the fulfilment of international agreements to reduce energy use and greenhouse gas emissions, as well as promoting higher quality building with a greater comfort of living for users and lower costs throughout the building's lifecycle. Current trends and efforts in the EU and around the world show that in future the use of methods for assessing buildings according to the principles of sustainability will be increasingly important or even compulsory for certain projects (public procurement). In future we can also expect powerful tools for the rationalisation of the assessment process. Digital tools that are being developed on the basis of BIM (Building information modelling – computer planning with 3D objects that contain additional information; e.g. Archicad, Revit) and their integration with product databases and other tools, enable relevant indicators of how the building affects the environment throughout its lifecycle to be overseen in parallel. Building assessment according to the principles of sustainable development will be necessary in future and will become part of the planning process [König et al., 2010: 96-102], as it has become evident that it is most effective in this way. In future, research work in the field of comprehensive building assessment will focus on the preparation of methods that will be adapted to individual countries or regions and the preparation of local product databases that will be necessary for this.

Acknowledgements

This research has been supported by the Slovenian Research Agency (ARRS) through its junior researcher financing scheme. This article forms part of a doctoral study at the Faculty of Architecture of the University of Ljubljana.

References

Augenbroe, F., Malkawi, A., 2009, Sustainability Assessment in a Global Market. ZELL/LURIE Real Estate
Center: 63-78, http://realestate.wharton.upenn.edu/research/papers/full/675.pdf, <January, 2013>.
Berardi, U., 2011, Comparison of sustainability rating systems for buildings and evaluation of trends, WSBC Helsinki 2011, http://www.irbnet.de/daten/iconda/CIB_DC23179.pdf, <January, 2013>.
Birgisdottir, H., Hansen, K., 2012, Test of BREEAM, DGNB, HQE and LEED on two Danish office buildings, WSBC Helsinki 2011, http://www.irbnet.de/daten/iconda/CIB_DC23260.pdf, <January, 2013>.
BRE Global, 2013a, http://www.breeam.org/, <January, 2013>.
BRE Global, 2013b, Greenbooklive, http://www.greenbooklive.com/search/scheme.jsp?id=202, <July, 2013>.
Ciampa, C., Hartenberger, U., 2012, Going for green, Sustainable Building Certification Statistics Europe, RICS.
Cole, R. J., 2010, Building Environmental Assessment in a Global Market. SB10 Seoul: 124-127.
Conte, E., Monno, V., 2012, Beyond the buildingcentric approach: A vision for an integrated evaluation of sustainable buildings. Environmental Impact Assessment Review 34: 31-40.
DGNB, 2013, http://www.dgnb-system.de, <July, 2013>.
Eberl, S., 2010, DGNB vs. LEED: A comparative Analysis, CESB10 Prague: 1-5.
Ebert, T., Essig N., Hauser, G., 2011, Green building certification systems, München: Institut für internationale Arhitektur-Dokumentation.
Eurostat, 2012, Consumtion of energy, http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/ Consumption_of_energy, <January, 2013>.
Fowler, K.M., Rauch, E.M., 2006, Sustainable Building Rating Systems: Summary, Pacific Northwest National Laboratory, http://www.wbdg.org/ccb/GSAMAN/sustainable_bldg_rating_systems.pdf, <January, 2013>.
Green Building Council Slovenia, 2013, http://www.gbc-slovenia.si/2012/10/31/certificiranje-trajnostnih-nepremicnin-pilotna-faza-dgnb-sodelovanje-brez-prijavne-takse/#more-640, <January, 2013>.
iiSBE, 2013, http://www.iisbe.org/, <January, 2013>.
IPCC, 2007, Climate Change 2007: Synthesis Report. Geneva, http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf, <March, 2013>.
Kajikawa, Y., Inoue, T., Goh, T.N., 2011, Analysis of building environment assessment frameworks and their implications for sustainability indicators. Sustainability Science, 6(2): 233–246.
König, H. et al., 2010, A life cycle approach to buildings, München: Institut für internationale Arhitektur-Dokumentation.
Lowe, C., Ponce, A., 2008, UNEP-FI / SBCI'S Financial & Sustainability Metrics Report. An international review of sustainable building performance indicators & benchmarks, BRE / CSTB, http://www.unepfi.org/fileadmin/documents/metrics_report_01.pdf, <January, 2013>.
Lützkendorf, T. et al., 2011, Next generation of sustainability assessment – top down approach and stakeholders needs. WSBC Helsinki 2011.
Mateus, R., Bragança, L., 2011, Sustainability assessment and rating of buildings: Developing the methodology SBToolPT–H. Building and Environment, 46(10): 1962–1971.
Reed, R. et al., 2009, International Comparison of Sustainable Rating Tools. JOSRE, 1(1), 1–22, http://www.costar.com/josre/JournalPdfs/01-Sustainable-Rating-Tools.pdf, <January, 2013>.
Rockstroem, J. et al., 2009, Planetary Boundaries: Exploring the Safe Operating Space for Humanity. Ecology and Society 14(2): 32.
Šijanec Zavrl, M., 2010, Trajnostne, zelene stavbe v teoriji in praksi, in Vukelić, Ž. (ed.) Trajnostno gradbeništvo & zelena javna naročila – Conference proceedings, Ljubljana, IZS: 25-30.
Šijanec Zavrl, M., Žarnič, R., Šelih, J., 2009, Multicriterial sustainability assessment of residential buildings. Baltic Journal on Sustainability 15(4): 612-630.
USGBC, 2013 http://new.usgbc.org/, <June, 2013>.
ZKG, 2012, Zgodovina projekta ZKG, http://www.gi-zrmk.si/GC/dejavnostZgodovinaZKG.aspx, <November, 2012>.

Legislation and standards

ISO, 2013, ISO/TC 59/SC 17 Sustainability in buildings and civil engineering works, http://www.iso.org/iso/iso_technical_committee?commid=322621, <July, 2013>.
SIST, 2013a, Ravnanje z okoljem / Environmental management, http://www.sist.si/index.php?option=com_content&view=article&id=113&catid=39&Itemid=161&lang=en, <July, 2013>.
SIST, 2013b, TC: TGO: Trajnostnost gradbenih objektov / Sustainability in construction works, http://www.sist.si/ecommerce/catalog/tc_search.aspx?tc=96e7cea7-bc47-46c6-8946-ce685c2bed4a, <July, 2013>.
ZeJN, 2012, Uredba o zelenem javnem naročanju, neuradno prečiščeno besedilo št. 1, http://zakonodaja.gov.si/rpsi/r04/predpis_URED5194.html, <November, 2012>.

Jernej Markelj, young researcher
jernej.markelj@fa.uni-lj.si
UL Faculty of Architecture

doc. dr. Manja Kitek Kuzman
manja.kuzman@bf.uni-lj.si
UL Biotechnical Faculty, Department of Wood Technology

prof. dr. Martina Zbašnik Senegačnik
martina.zbasnik@fa.uni-lj.si
UL Faculty of Architecture

Translation
Marko Petrovič

iz recenzije / *reviewer notes*

Članek z naslovom "PREGLED METOD VREDNOTENJA STAVB PO NAČELIH TRAJNOSTNEGA RAZVOJA" predstavlja pregledni znanstveni članek s področja vrednotenja nepremičninskih projektov, kamor se poleg upoštevanja celotnega življenjskega ciklusa nepremičnine v vrednotenje v zadnjem času vse bolj vključujejo tudi kriteriji trajnostnega razvoja. Z razvojem paradigme trajnostnega razvoja in njeno konkretizacijo se množica različnih metodologij grupira, metodologije same po sebi pa postajajo vse bolj aplikativne. Zato so tudi v tem članku predstavljene le najbolj reprezentativne metodologije vrednotenja stavb in analizirane njihove bistvene značilnosti. Vendar navedene metodologije niso neposredno uporabne v vseh okoljih, kar je odločujoče spoznanje za nadaljevanje raziskovanja na obravnavanem področju. Skupni so lahko cilji, med katerimi so pogosto omenjeni: zmanjševanje rabe energije, znižanje izpustov toplogrednih plinov, spodbujanje kakovostne gradnje z večjim udobjem za uporabnike in podobno. Poti za dosego teh ciljev so lahko različne, odvisne so od stanja na tem področju v lokalnem okolju in seveda tudi od možnosti, ki jih ponuja. Zato tudi avtorji članka v zaključku predstavijo nekatera izhodišča za vpeljavo tovrstne metodologije v Republiko Slovenijo.

izr. prof. dr. Maruška Šubic Kovač
Univerza v Ljubljani
Fakulteta za gradbeništvo in geodezijo
Institut za komunalno gospodarstvo