BUILDING ENERGY PERFORMANCE (BEP-TR) AS A CALCULATION METHODOLOGY : COMPARISON WITH OTHER ENERGY CERTIFICATIONS

SELCEN NUR ERİKCİ[1]

ABSTRACT

In this study, differences between BEP-TR National Building Energy Performance Calculation Methodology and the widely used environmental assessment methods for buildings are investigated. Parameters as paths taken in the calculations, priorities, energy classifications through the simulation tools of the methods are evaluated. The most appropriate system or implementation for Turkey is mentioned along the comparison of these assessments in terms of energy classifications. The necessity of an energy performance calculation methodology is emphasized according tolocal properties and preconditions.

Key words: BEP-TR National Calculation Methodology, Building Energy Performance Certification, BREEAM, LEED, Energy Classification.

1. INTRODUCTION

In parallel with the development of information and communication technologies, the sensitivity displayed by the designers for making the buildings environment friendly has increased and in various countries around the world, energy-effective building certification systems have been developed. Global climate change and ever-decreasing fossil energy resources have resulted in energy effectiveness and energy efficiency concepts especially in construction sector. Among these systems, there are certification systems such as CASBEE, Green Star, SBTool, BEES, ECOPROFILE besides those which are worldwide known and commonly used such as BREEAM and LEED. For the buildings to be designed energy-effective, all these systems audit various procedures in the design process, determine the results of these audits with scoring method, and find the energy class of the examined building with the evaluations as a result of determined scores according to the reference building. Carbon emission amounts occurring depending on the required energy for

[1] Res. Asst. Yeni Yüzyıl University, İSTANBUL

heating, cooling, lighting and ventilating of the building and on consumption of this energy and building energy performance which is "the consumed amount of energy for providing the comfort conditions to meet the different requirements connected with the standard use of the building" [1] are important factors in energy-effective building classification.

In our country, studies on Calculation Method of Energy Performance of Buildings (BEP-TR) which were started in December 2008 by R.T. Ministry of Public Works and

Settlement were completed in December 2009 and in December 2010, it became official. BEP-TR method which will be used for issuance of Energy Identity Certificate (EIC) which is mandatory for all buildings in EU countries was developed for Turkey conditions via the methods stipulated by EPBD (Energy Performance Building Directive). BEP-TR which is the national calculation method is based on "Simple Hourly Dynamic Calculation Methodology". This mandatory system was formed in a way not to include detailed energy simulation tools based on the requirement to follow more simple methods for ease of use and quick certification. EIC, which became mandatory for buildings to be made after July 2011 and for the existing buildings until 2017, has a great importance in ensuring energy efficiency in Turkey.

When parameters affecting the energy performance of buildings (light, climate, passive system parameters, parameters of electrical and mechanical systems, etc.) and many variables within these parameters are evaluated, the certification systems developed to calculate the lifelong energy costs of buildings use detailed energy simulation tools. BEP-TR which is the national calculation method is based on simple hourly dynamic calculation methodology. Not having a certain common evaluation and not stating the energy classes of these buildings with equal values in these studies performed with this calculation methods form the basis of the study. The importance of being able to carry out accurate studies on using energy effectively and saving energy from the design stage to the end of building process is emphasized in terms of architects. In this study, the differences between BEP-TR and other certification systems' energy performance scoring evaluation systems of buildings and inequalities between the results will be stated with comparative analyses and evaluated. This study is the comparative evaluation of energy simulation programs used in determination of energy class values obtained as a result of studies performed with these systems with the aim to determine the energy classes of buildings, the data taken as basis by these programs and resulting building energy classes. This study is limited with the examination of BEP-TR, LEED and BREEAM systems.

2. CALCULATION METHOD OF ENERGY PERFORMANCE OF BUILDINGS

National Calculation Method of Energy Performance of Buildings - BEP-TR which became mandatory for existing buildings and buildings to be made (residence, buildings for commercial and service purposes, etc.) by being published in Official

Gazette as of 7 December 2010 will be used to form the EIC of all these buildings. Therefore, it is aimed to create awareness about the energy consumed by the buildings in the society and their damages to the environment. It is aimed to find the energy classes of buildings used for different purposes and decrease their damages to the environment with the measures to be taken.

"Calculation Method of Energy Performance of Buildings includes
1.Calculation of net energy amount required for heating and cooling of the building,
2. Determination of total heating and cooling energy consumption of the building considering the losses resulting from systems which will meet net heating and cooling energy requirement, and system efficiencies,
3.Determination of ventilation energy consumption,
4.Calculation of lighting energy requirement and consumption for time of no daylight utilization and areas where daylight is not effective by considering the effects of daylight in the buildings,
5.Calculation of energy consumption necessary for sanitary hot water [2]".

Building net energy inputs and outputs included in the calculations are seen in Figure 1.

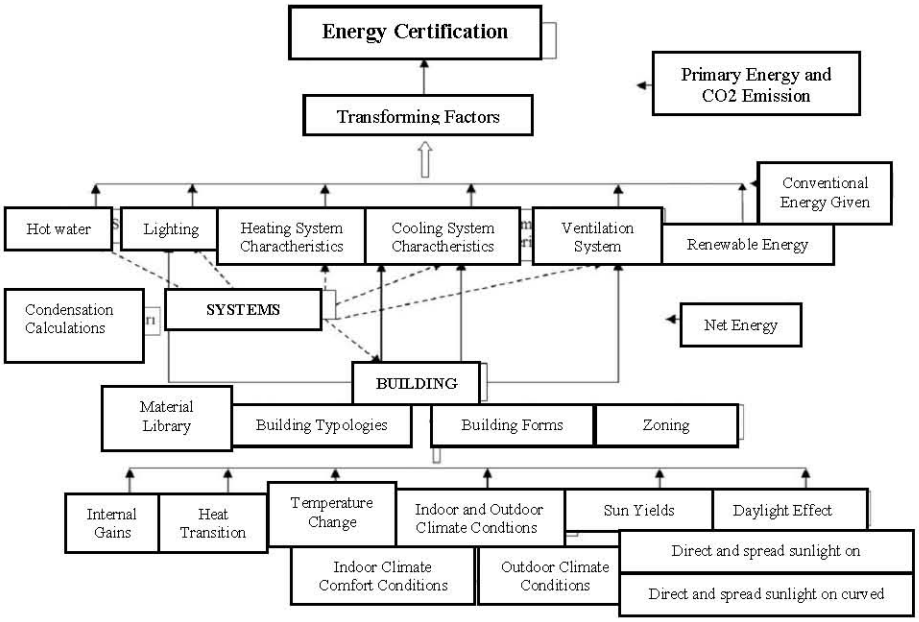

Figure 1. Net Energy Data Inputs and Outputs[3]

When the above data are considered, BEP-TR consists of three parts which are

- Meeting the building heating and cooling net energy requirement
- Determination of lighting loads and

- Calculation of energy consumption with the mechanical systems which will fulfill the building net energy requirement.

"TS ISO 13790 suggests three models in calculating building heating and cooling net energy amount;

- Monthly / seasonal static calculation method,
- Simple hourly dynamic calculation methodology,
- Detailed dynamic calculation method[4]".

BEP-TR calculation method was formed using related EU standards and when required ASHRAE and Turkish standards. The method used is "Simple Hourly Dynamic Calculation Methodology". The basis of choosing this method is impracticability of detailed dynamic methods, not essentially requiring to determine the heating and cooling seasons as it is in monthly / seasonal static methods and being able to calculate the net energy amount in changeover seasons.[5]

"Simple hourly dynamic calculation methodology;

- is a half dynamic calculation method. Hourly climate data and time schedules are used.
- RC (resistance-capacity) model can reflect hourly thermal behavior of the building in a more real-like way.
- It allows for comfort conditions to be identified depending on the operative temperature.
- It calculates the operative temperatures with hourly calculation steps and required net energy which will provide for the comfort requirements according to hourly time schedule[6].

Methods which calculate only the heating requirement taking as basis the climate data due to the geographical positions in general of the EU countries and which use monthly / seasonal static calculation method are used and thereby sun yields and shading effects are not considered. Determining cooling requirements of our country is an important parameter which should be emphasized just like heating requirement net energy amount and therefore it is ensured that in BEP-TR sun yields and shading effects are calculated and building net energy amounts are found. In determining heating and cooling energy requirements, direction of the building and daylight affecting the building surfaces, inclination of surfaces which are exposed to sunlight and sun control elements are simply included in the calculation.
BEP-TR algorithm makes calculations in a level which can be deemed sufficient basically for residence and office buildings. However, since there are points which were left indefinite and incomplete in ISO 13790 and other standards it was directed (sun yields, shading effects, relations with zone in heating transitions, internal yields, etc.), analyses were made according to EU standards.
BEP-TR calculations vary according to functions of each building and are based on zoning and including in calculation. In the stage of zoning the building, each floor for detached houses and each independent unit (flat) in apartment type residences are considered as a separate zone. In calculations made using the method, heat losses

occurring via conduction and convection are taken from the tables which include thermal transition coefficients (U values) for glass and joinery types in our country. In Figure 2, structure components used in BEP-TR calculations are given as zones. Locations which are affected by the outside weather are considered as "climatized zone" and locations which do not interact with outside weather are considered as "non-climatized zone". These zones in which air flow occurs via wall, flooring and foundation and joinery are grouped and separated into types.

"Sources which are accepted as causing air flow in BEP-TR are as follows

- Natural ventilation through windows and doors,
- Leaks coming through openings and cracks in structure shell (infiltration),
- Air flow from non-climatized adjacent zone (winter garden, etc.) and
- Air flow from mechanical ventilation systems [7]".

Temperature correction factors are used in including heat losses arising out of such air flows in calculation. The required details are considered accurately according to the source of air flows and thereby heat transitions/losses are included in the calculations.

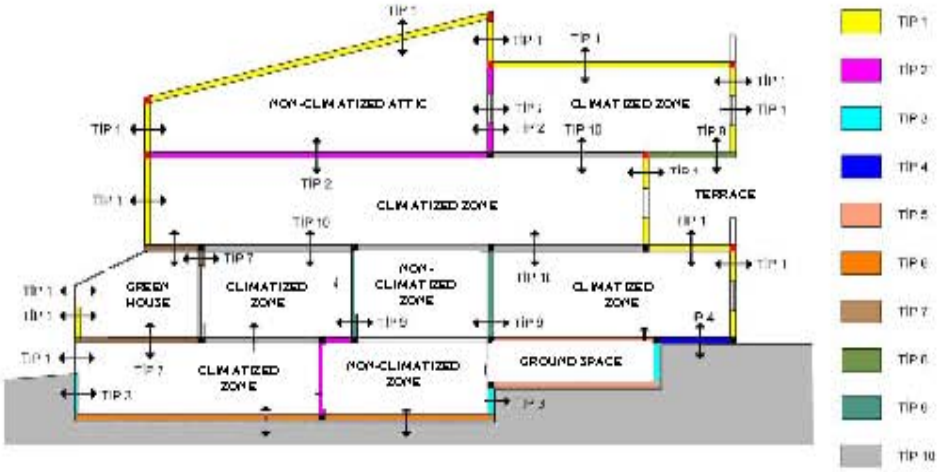

Figure 2. Structure Components Which Zone Thermal Conditions for Heat Transition Calculations[8]

Since following more simple methods is taken as basis for providing ease of use in BEP-TR calculation method and for fast certification, related standards were used in determining accepted internal yields arising out of humans and devices according to the function of the building. It is assumed that buildings with same function are used in same hours in daily time zones.
It is ensured that building shell components are gathered in two main groups which are opaque and transparent components and yields resulting from insulation effect are calculated. In this stage, parameters such as sun yields gathered via transparent

and opaque components in the building, obstacles in the exterior wall, shading effects of the buildings on each other are taken into consideration.
After zoning the buildings, determining building components according to types considering heat transitions / losses, including internal yields arising out of humans and devices (lighting devices, mechanical goods, hot water utility, etc.) and calculating sun yields of the building via the transparent and opaque components, heating and cooling net energy requirement of the building can be calculated. In calculating net energy amount, "resistance-capacity" model which is suggested in EN 13790, but whose details are not included for not being used commonly is used.
This model calculates the heating or cooling requirement of the building's each previously determined zone hourly. In this stage, thermal capacity of the building is considered as an approximate value and an average mass temperature is calculated. *Operative temperature* which is defined as indoor comfort consists of temperature which is hourly calculated by the model and cumulative average of thermal mass temperature of the building. If this operative temperature is lower than the temperature accepted for heating, that zone needs heating, if it is higher than temperature accepted for cooling, it needs cooling. If operative temperature is a value between temperatures determined for heating and cooling, that zone needs neither heating nor cooling [8].
Calculation Methodology of Energy Performance of Building which is a national calculation method has been prepared for our country and is based on existing measurements and evaluations which are used in terms of geographical, architectural and construction techniques. It aims to calculate net energy amounts of buildings, determine their energy classes and create certain awareness in issues such as harms to the environment and CO_2 emission amounts. Thanks to the application in new buildings to be built as of July 2011 and imposing an obligation to give EIC to the buildings, it is among the most important expectations that it will play an important role in terms of exhausting energy sources and accelerating the solution processes for them.
In energy performance evaluation, separate classifications are made for energy consumption and CO_2 emission. The interims in the table define the BEP-TR performance values.

Table 1. Energy Classes According to EP Building Performance Values [9]

Energy class	Ep interims
A	0–39
B	40–79
C	80–99
D	100–119
E	120–139
F	140–174
G	175-…

3. DEFINING OTHER INTERNATIONAL CERTIFICATE CALCULATION METHODS

International certificate methods which will be compared with each other and with BEP-TR national calculation method in the study are chosen among the widely known certificate programs in the world. LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), GREENSTAR, CASBEE (Comprehensive Assessment System for Building Environmental Efficiency), SBTool (Sustainable Building Tool-Canada), GBC (Green Building Challenge) are among the most used certificate systems in the world.
Especially BREEAM and LEED are the primary international systems which are used most in building and promoting the energy-effective buildings. In both systems, analyzing the building energy amounts and determining energy class are taken as basis in the process from design stage to auditing during construction.
LEED is one of the certificate systems which were developed by US Green Building Council (USGBC) and which have a global brandname value. BREEAM is an internationally recognized certificate system which makes the energy class identifications of the non-residential buildings in England in 1990 and which has been commonly used in England and Europe.

LEED measurements are performed in the following subjects

- Sustainable premises
- Water efficiency
- Energy & Atmosphere
- Materials & Resources
- Indoor quality
- Settlements & Connections
- Awareness & Training
- Innovation in design
- Regional priority

BREEAM calculations are performed in the following subjects

- Building Management
- Health and Comfort
- Energy
- Water
- Land Use and Ecology
- Transportation
- Material
- Wastes
- Pollution
- Innovation

and building gradings are formed with scoring system.[10]
In both systems, detailed simulation tools are used. Evaluating buildings' annual heating and cooling requirements and consumptions and daylight lighting performances is only possible with the use of these simulation tools. Detailed simulation tools which are used in determining building energy performances can make simultaneous-multiple zone calculation (zones in which thermal conditions are different and in which thermal relations of these zones with each other are simultaneously considered).[11] Energy Plus is a detailed simulation method which is supported by USA Ministry of Energy and used most commonly in the world and in our country. In addition, they support detailed simulation tools such as DesignBuilder, Ecotect, DOE-2 to be used in energy modeling. EnergyPlus is a detailed simulation program which dynamically calculates the energy amount consumed by the buildings in design stage or existing buildings due to heating, cooling and ventilation loads and displays the energy performances of these buildings in design stage before the construction and allows for the designer to choose the most proper one for the project.[12] In detailed simulation tools, many program modules work together and make the necessary calculations to estimate the energy used by the building for heating and cooling. It is necessary to analyze the "building, system, installation" parameters which form the three main component in energy consumption. Especially in energy certification evaluations of complex buildings (hotel, education, health buildings, etc.) whose energy consumptions are very high, which have different thermal requirements and which consist of many places, detailed simulation tools are used.

3.1. COMPARING LEED and BREEAM CERTIFICATE SYSTEMS

LEED and BREEAM take as basis the abovementioned criteria and make analyses by choosing the most proper one according to usage targets of detailed simulation tools. As a result of the analyses, they can identify building energy performances according to scoring systems. LEED scoring system uses a scoring system of maximum 110 points and BREEAM uses a system of percent weight over 100 points.[13] Both certificate system generally require the following data

- Construction records
- Architectural drawings/diagrams
- Engineer calculations
- Energy model report/Energy Performance Certificates
- Written statements by project owner or project developer about the project[14]

Both certificate systems use their own existing standards and plans. In the beginning stage, two different teams, design and audit, consisting of separate experts in two individual topics are formed. Regularly collecting the data from the individuals in the design team, audit team perform the audit process according to the standards of the systems (individual standards arranged for LEED and BREEAM). Energy performances of the buildings are found for certain prices. In addition, BREEAM

may perform site audit for the certificate to be valid when necessary. There is no site audit in LEED.

Table 2. BREEAM Technical Details[11]

BREEAM CATEGORIES	**New Buildings, Additions, Big restorations**	**Fit-Out**
Management	12	13
Health and Wellbeing	15	17
Energy	19	21
Transportation	8	9
Water	6	7
Material	12.5	14
Waste	7.5	8
Soil Use and Ecology	10	No
Pollution	10	11

Table 3. BREEAM Classification[11]

BREEAM CLASSIFICATION	SCORE (%)
FAIL	<30
PASS	>=30
GOOD	>=45
VERY GOOD	>=55
PERFECT	>=70
EXTRAORDINARY	>=85

Table 4. LEED Technical Details[11]

LEED CATEGORIES	New Buildings, additions, big restorations
Sustainable Lands	26
Water Effectiveness	10
Energy and Atmosphere	35
Materials and Resources	14
Indoor Air Quality	15
TOTAL	100
BONUS SCORES	
INNOVATION AND DESIGN	6 (If 5 innovation credits +1 credit LEED AP is used)
REGIONAL CREDIT	4
TOTAL	110

Table 5. LEED Classification[11]

LEED CLASSIFICATION	SCORE
CERTIFIED	40–49
SILVER	50–59
GOLD	60–79
PLATINUM	80 points and above

NOTE: These scores depend on the certification systems' (BREEAM and LEED) calculation methods. They are totally automatic and come out from the software. They are variable both with the project's features and also with the program that is used - BREEAM or LEED-.
In the tables above, the categories used in scoring systems of BREEAM and LEED certificates and the scoring evaluation classifications they get according to these categories are seen. Measurements are made over similar parameters in both certificate systems, however scoring evaluations differ from each other quite much. Similarly, there is a standardized preconditions list for both systems. These preconditions determined in BREEAM can be said to be too much for LEED. It is known that LEED give more right to decide to the designer than BREEAM.[15] The interims for different building typologies and total scores to be obtained in LEED show difference.
Unless applications fulfill preconditions determined for BREEAM degrees such as

- Commissioning
- Effect of construction site
- Building user guide
- Decreasing CO_2 emissions
- Water consumption
- Storing recyclable wastes

they cannot have certificates. [16] For LEED, 8 parameters similar to the abovementioned topic are included in the precondition list of the system.
Although both systems generally have similar properties, BREEAM focuses more on environmental effect and LEED prioritizes health and comfort of the user. [17]. Despite of the fact that the criteria on which both systems are based on have similar properties, England's legislation's having more strict rules than those in America makes application of BREEAM much more difficult than LEED. Accordingly, scoring systems also differ due to having different priorities of the criteria.[18]

4. COMPARATIVE EVALUATION OF BEP-TR WITH OTHER SYSTEMS

National building energy performance methodology, BEP-TR, which uses simple hourly semi-dynamic calculation method exhibits different properties and evaluations from BREEAM and LEED which use detailed dynamic calculation methods.
With the publication of BEP-TR as regulation in Turkey in December 2008, it became mandatory to get EIC for buildings to be built as of June 2011 which have an indoor area of 1000 m². However, it is necessary for national calculation method BEP-TR to make correct calculations in every building typology and by including any kinds of criteria. These calculations examine the thermal behavior of the building in hourly time frames and include them in the calculations. In addition, both heating and cooling net energy amounts should be calculated due to geographical position and climatic data of our country. Besides, it also considers the shading and insulation conditions which are among the most important parameters for our country. BEP-TR is an appropriate method for simple residence buildings whose thermal behaviors are not very different and which do not include many zones. The main purpose in the method is to find the energy consumption amounts of the buildings in a simplified way.

BREEAM and LEED are the certificate systems which have global brandname value in the entire world, which are commonly used and which have local calculation types arranged by various countries according to their own data. EU member states and USA make it obligatory to determine the energy classes according to CO_2 emission amounts produced by the buildings and this does not establish any obligation for the countries in terms of choosing the certificate system which will realize this. These are the systems which are arranged to perform its calculations during the lifetime of the building in terms of decreasing building energy consumption and CO_2 emission amounts. They make the building energy modelings of systems which use detailed dynamic calculation methods. Detailed simulation tools are the interfaces which can make simultaneous calculations with many modules in their contents between zones whose thermal conditions are very different from each other. Therefore, making energy modelings of hotels, healthcare buildings and non-residential buildings used for commercial purposes and calculating their net energy amounts are only possible with detailed simulation tools.

Although the criteria and preconditions they use show similarity, there are certain differences especially in the parameters they set as priority. The availability of differences especially in terms of score evaluations in two systems which make calculation with detailed dynamic methods and which have similar parameters is important for us to be able to see its differences with a method which uses a simple hourly calculation method such as BEP-TR.

There are ongoing studies on the arrangements which use detailed dynamic methods for BEP-TR to be applied in complex building calculations. In addition, Turkish Green Building Council (TGBC) which was founded in 2007 signed agreements with BRE-GLOBAL in 2009, with DGNB in 2010 and with LEED-INTERNATIONAL in 2011. The short-term aim of the council is arrangement of the existing systems such as BREEAM, LEED, IISBE, Green Star, CASBEE or DGNB for Turkey conditions. In long-term, the aim is to form a system for our country. [19] There are ongoing studies performed by TGBC for developing BREEAM which is one of the oldest environmental evaluation systems under the adaptation resolution taken in Turkey in 2008.

5.CONCLUSION

These methods constitute a sample for the measurement tools used. They include criteria which should be observed and followed in architectural, design, mechanical, electrical installation solutions according to construction order of the building and in all of the construction processes. Countries require calculation methods which are arranged according to their local condition and properties. The method which is prepared by prioritizing the local dynamics in points such as climatic data, priorities, energy classification, materials used will give the best result. Renewability criterion should be considered according to changing conditions and properties in time.

In this case, a calculation method should be chosen by taking into consideration the conditions of our country (geographical, climatic, architectural, materials, etc.) and in a way to be applicable for all building ty

pologies. Neither BEP-TR which uses simple hourly calculation method neither systems which use detailed dynamic calculation methods such as BREEAM, LEED can produce a complete solution choice for our country. All criteria included in the content of the methods should be developed for Turkey conditions improvement and applicability should be provided in the most convenient level in all buildings to be made.

REFERENCE

[1] Gali, G., Corgnati, S.P., Yılmaz, A.Z., "Kompleks Binaların Enerji Sertifikasyonu Açısından Analizleri: Standart ve Detaylı Simulasyon Araçlarının Karşılaştırılması", X. Ulusal Tesisat Mühendisliği Kongresi, İzmir, 2011, 795-807.

[2] Bayındırlık ve İskan Bakanlığı, Yapı İşleri Genel Müdürlüğü, Binalarda Enerji Verimliliği Şube Müdürlüğü, "Binalarda Enerji Performansı Yönetmelik, Hesaplama Yöntemi, Referans Bina ve Enerji Sınıflandırması, Yazılım, Süreçler", Aralık 2009.

[3] Bayındırlık ve İskan Bakanlığı, 2008, http://www.bep.gov.tr/sunumlar/bep.pdf

[4] EN 13790: Energy Performance of Buildings – Calculation of Energy Use For Space Heating and Cooling, 2007.

[5] Yılmaz, A.Z., "Binalarda Enerji Verimliliği ve Yeşil Bina Sertifikasyonu için Bina Enerji Modellemesi", Ekoyapı Dergisi, 1, 2010.

[6] "BEP-TR Hesaplama Metodolojisi", Resmi Gazete, Sayı: 27778, 07.12.2010.

[7] "Binalarda Enerji Performansı Yönetmeliği", Resmi Gazete, Sayı: 27075, 05.12.2008.

[8] Yılmaz, A.Z., "Bina Enerji Performansı Ulusal Hesaplama Yöntemi (BEP-TR) ile Isıtma ve Soğutma Enerjisi İhtiyacının Hesaplanması", X. Ulusal Tesisat Mühendisliği Kongresi, İzmir, 2011, 765-778.

[9] Bayram, M., "BEP-TR Hesaplama Yönteminde Referans Bina Kavramı ve Enerji Sınıflandırması", X. Ulusal Tesisat Mühendisliği Kongresi, İzmir, 2011, 755-762.

[10] http://www.ekomim.com/hakkimizda.html

[11] Erten, D., Yılmaz, A.Z., "LEED ve BREEAM Sertifikalarında Enerji Performans Değerlendirilmesinin Karşılaştırılması", X. Ulusal Tesisat Mühendisliği Kongresi, İzmir, 2011, 1541-1552.

[12] Aktacir, M.A., Nacar, M.A. , Yeşilata, B., "Binalarda Enerji Verimliliği Amaçlı Yazılımlar Üzerine Kısa Bir Değerlendirme", X. Ulusal Tesisat Mühendisliği Kongresi, İzmir, 2011, 853-862.

[13] Erten, D., "LEED ve BREEAM Sertifikalarının Karşılaştırılmalı İncelenmesi", Uluslararası Sürdürülebilir Yapılar Sempozyumu (ISBS), Ankara, 2010.

[14] Erten,D., Henderson, K., Kobaş, B., "Uluslararası Yeşil Bina Sertfiikalarına Bir bakış: Türkiye İçin Bir Yeşil Bina Sertifikası Oluşturmak İçin Yol Haritası", V.

International Conference on Construction in the 21th Century(CITC-V): Collabartion and Integration in Engineering, Management and Technology, İstanbul, 2009, 1701-1708.

[15] Erten, D., "Ekolojik Dönüşümde Bir Araç Olarak Yeşil Bina Değerlendirme Sistemleri", Ekoyapı Dergisi, http://ekoyapidergisi.org/index.asp?action=yazidetay&id=108.

[16] http://www.bre.org, 2008.

[17] Anon., "Assessing The Assessor, BREEAM Versus LEED", Sustain Magazine, Vol.09, Sayı.6, s:30-33, http://www.breeam.org/filelibrary/BREEAM_v_LEED_Sustain_Magazine.pdf, 2011.

[18] Utkutuğ, G., "Sürdürülebilir Bir Geleceğe Doğru Mimarlık ve Yüksek Performanslı Yeşil Bina Örnekleri", X. Ulusal Tesisat Mühendisliği Kongresi, İzmir, 2011, 1517-1538.

[19] Çevre Dostu Yeşil Binalar Derneği, 2007, http://cedbik.org/sayfalar.asp?KatID=3&KatID1=25&ID=25