A comparison of LEED and BREEAM green building assessment tools and their relevance for Greece

Seintou Antonia

SID: 3302110041

SCHOOL OF SCIENCE & TECHNOLOGY

A thesis submitted for the degree of

*Master of Science (MSc) in Energy Systems*

OCTOBER 2012
THESSALONIKI – GREECE
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SID: 3302110041

Supervisor: Prof. Isaac Meir
Supervising Committee Members:

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Abstract

This dissertation was written as a part of the MSc in Energy Systems at the International Hellenic University. Here goes a summary of the dissertation.

Buildings have a huge impact on the environment from the beginning of their life till the end of it. Therefore, processes that are environmentally responsible and resource-efficient throughout the building’s life are of great importance. The aim is the sustainable performance of the building and to this direction, several environmental and management tools have been developed which are known as green building assessment tools. The most representative rating systems are BREEAM and LEED. The first part of this dissertation focuses on the description of these two very important assessment tools. Firstly the Leadership in Energy and Environmental Design (LEED) is presented in the dissertation. It was developed in the United States in 1998 and it promotes a whole-building approach to sustainability by measuring performance in six categories in order to achieve human and environmental health. LEED can be applied to several types of buildings.

The Building Research Establishment’s Environmental Assessment Method (BREEAM) is the second assessment tool that is presented. BREEAM evaluates the building’s performance in eight categories by awarding points for each one and covers a range of building types.

After the description of these two assessment tools their differences and similarities are pointed out and at the end of the first part of the dissertation, the comparison conclusions between the two assessment tools are drawn and presented.

The second part of the dissertation focuses on a local scale. The previously described tools are related to the Greek building industry.

First of all the Greek general legislation for buildings is presented and of course the Directive 2002/91/EC for the energy performance of buildings which introduces a holistic approach to the energy design of buildings, as well as its recast, Directive 2010/31/EC. There are also Technical Guidelines that are taken into account, which were specifically issued according to the Greek climatic conditions and building criteria and are used for the issuance of the energy performance certificate of the building.
At the end, the different categories and criteria of the two main assessment tools are linked to the Greek building sector and conclusions are drawn as to whether it is possible to relate these tools to the Greek reality. At the same time, through these conclusions suggestions are made for further developments on the Greek building sector that have to do with the general improvement of the sector.

At this point I would like to thank my supervisor, Associate Professor at the Ben-Gurion University of the Negev, I. Meir, for his guidance, his advice and support and most of all for his patience throughout the time of the preparation of this thesis.

I would also like to thank my family and the people who are close to me for believing in me and for showing me their support, their encouragement and mostly for being patient over the last months.

Seintou Antonia

October 2012
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1 Introduction

1.1 Sustainability and the building sector

The building sector is responsible for 40% of the total energy consumption on a national and European level. The final energy consumption in the European Union goes up to 1.168 Mtoe or 2.4 toe /capita. Such energy consumption has high cost and besides that, has as a result the burdening of the atmosphere with high amounts of CO₂. In Greece specifically, 44% of the amount of CO₂ emitted to the atmosphere is related to the building sector, while 21% to transport, 28% to industry and 7% to other uses (EAA, 2007).

Buildings have a huge impact on the environment from the beginning of their life till the end of it (from cradle to grave) through the processes of extraction of materials, of transportation, of construction of the building, its maintenance and use and finally the demolition process. Building operation requires spending significant amounts of energy, water, and materials and at the same time is responsible for generating great amounts of waste. (S. Kubba, 2010). The construction of buildings consumes 40% of the stone, sand and gravel, 25% of the virgin wood, 40% of the energy and 16% of the water used every year in the world. The energy consumed during the actual use of a building is estimated to be about 80-90% of the total energy, for a lifetime of 50 years (Arena and de Rosa, 2003). Considering the dwindling of natural resources it has therefore become evident that a more sustainable approach in the building sector has become a necessity.

During the last decade many changes have taken place in the construction industry towards the construction of more environmentally responsible buildings. Sustainable buildings use resources in a more efficient manner than regular buildings do. Green building represents a change in the way we understand, design and construct today. Its goal is to improve current design and construction practices and standards so that the buildings we build today will last longer, be more efficient, cost less to operate, and contribute to healthier living and working environments for occupants, thereby also helping to increase productivity. Green building is also about increasing the efficiency
with which buildings and their sites utilize energy, water, and materials, protect natural resources, and improve the built environment. However, when building ‘green’ one should keep in mind the life cycle impacts of their decisions, in order to have higher environmental and economic benefits. This means that a whole building approach is vital for a project to be successful.

It should be pointed out that the earlier the stage that the green building techniques are incorporated, the better the results of the efficiency of the building.

The strategies used when building Green in order to reduce the impact on human health and the natural environment are:

- The efficient use of energy, water, and other resources
- Protecting the health of a building’s occupants
- Improving employee productivity
- Reducing waste, pollution, and environmental degradation (S. Kubba, 2010).

### 1.2 Benefits of going “Green”

Sustainable/green building offers an opportunity to create an environmentally efficient building through the better use of the available natural resources while at the same time offering a better living environment for the users.

The main economic benefits of utilizing the environment more efficiently, reducing environmental impact, include: water usage minimization, reduction of waste and their disposal costs, reduction of the use of pollutants and their disposal costs, encouraging recycling and reuse of materials, encouraging development of local markets for the use of local materials thus saving on transportation costs.

The main economic benefits of using energy more efficiently include: saving on operating costs over the life of the building and enhancement of the value of the building.

Finally, the main economic benefits of improving indoor environment thus producing healthier places to work include: the increased productivity due to a healthy working environment, the reduction of absences in the work place and the increase of morale and corporate loyalty.
Hannah Carmalt, a project analyst with Energy Market Innovations, says: “The most intuitive explanation is that productivity increases are due to better occupant health and therefore decreased absenteeism. When workers are less stressed, less congested, or do not have headaches, they are more likely to perform better” (S. Kubba, 2010).

1.3 Obstacles of going “Green”

One of the main obstacles when it comes to deciding whether to construct a sustainable building or a conventional one is the cost factor. Many, when constructing a house decide to follow the conventional road rather than building “Green” since the cost of the former seems to be less. However, especially when it comes to the energy systems of the houses, such decisions are a mistake. In the long run the better the energy improvement, the higher the pay-off after a certain period of time (payback period). Especially since the energy costs are vastly growing even the time of the amortization of the investment could be significantly reduced.

Another obstacle to consider is the lack of information around the process of building in a sustainable manner. Many house owners and even engineers are not familiar with the strategies of sustainable building. When not knowing the advantages and the benefits, one is more likely to decide to build in the conventional manner (S.Dirlich, 2011). This means that more information around the subject of Green building should be available and of course on the other hand home owners and engineers should be more eager on learning more about these techniques and their benefits.
1.4 Cost of going “Green”

As it was mentioned above, one of the most mistaken perceptions is that Green buildings cost more than the conventional ones.

The costs regarding green buildings can be divided into direct capital costs and direct operational costs.

Direct capital costs are costs associated with the original design and construction of the building and include interest during construction. Through the appropriate design and the use of only those systems that are needed for the proper operation of the building, any additional and unnecessary costs are eliminated.

Capital and operational costs are relatively easy to measure. On the other hand, measuring the effect of building green on the productivity of the occupants is not so easy to do, but is something to consider because of its importance.

Direct operating costs are those costs that have to do with the operation and maintenance of the building over its lifetime. The primary costs are those that have to do with the heating, cooling and maintenance of the building.

In the following table, the main influence of cost for green building projects in the case of LEED certification, the U.S. Green building scheme, is shown with their corresponding possible cost increases.

Table 1.1: Cost influencers for green building projects (source: Yudelson, 2009)

<table>
<thead>
<tr>
<th>Cost influencer</th>
<th>Possible cost increases</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Level of LEED certification sought</td>
<td>Zero for LEED-certified to 1-2 % for LEED Silver, up to 4% for LEED Gold</td>
</tr>
<tr>
<td>2. Stage of the project when the decision is made to seek LEED certification</td>
<td>After 50% completion of design development, things get more costly to change</td>
</tr>
<tr>
<td>3. Project type</td>
<td>With certain project types, such as science and technology labs, it can be costly to change established design approaches; designs for office build-</td>
</tr>
<tr>
<td>Cost influencer</td>
<td>Possible cost increases</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>4. Experience of the design and construction teams in sustainable design and green buildings</td>
<td>Every organization has a “learning curve” for green buildings; costs decrease as teams learn more about the process</td>
</tr>
<tr>
<td>5. Specific “green” technologies added to a project without full integration with other components</td>
<td>Photovoltaics and green roofs are going to add costs, no matter what; it’s possible to design a LEED Gold building without them</td>
</tr>
<tr>
<td>6. Lack of clear priorities for green measures and lack of a strategy for including them</td>
<td>Each design team member considers strategies in isolation, in the absence of clear direction from the owner, resulting in higher costs overall and less systems integration</td>
</tr>
<tr>
<td>7. Geographic location and climate</td>
<td>Climate can make certain levels of LEED certification harder and costlier for project types such as labs and even office buildings.</td>
</tr>
</tbody>
</table>

1.5 Concepts for environmental evaluation

The most famous environmental concepts are (Giamma, Papadopoulos, 2009):

1. Life cycle thinking (LCT) concept

LCT takes into consideration the impact of any product from cradle-to grave to include environmental impacts along its whole life cycle, process or activity

2. Life cycle management (LCM)

LCM’s goal is to have continuous environmental enhancement from a life-cycle point of view. It can use national or international standards and indicators.

3. Design for environment

Clean technology cares for the whole life cycle of the product.
4. Cleaner technology

It is a concept used in the industrial community to refer to preventing pollution and waste at source. Cleaner Production is defined by the UNEP -United Nations Environment Programme (UNEP, 2006) as “the continuous application of an integrated preventive environmental strategy applied to processes, products and services to increase eco-efficiency and reduce risks to humans and the environment”. Cleaner production requires (a) change of attitudes, (b) environmental management and (c) evaluating technology options.

5. Dematerialization

It refers to a considerable decrease in the amount of resources used to meet human needs, while increasing the quality.

6. Eco-efficiency

The term eco-efficiency was introduced by the World Business Council for Sustainable Development (WBCSD), 1993). It is defined as “the delivery of competitively priced goods and services, which satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle”.

7. Industrial ecology

“It is the multidisciplinary study of industrial systems and economic activities and their link to fundamental natural systems” (Allenby, 1999).

8. End-of-Life (EOL) management

It is the management of products at the time their functional life has ended when it enters the waste phase focusing on the environmental aspects of a product.

1.6 Tools for environmental evaluation

“Tools are operational methods based on concepts and supported by technical elements such as models and software”.

Environmental tools are based on the environmental concepts and may appear to have differences in terms of their structure, but their target is the environmental assessment and the environmental improvement. Tools are classified into analytical and operational ones (Giamma, Papadopoulos, 2009).
Analytical environmental tools

The most popular analytical environmental tools are:

1. Life-cycle assessment (LCA)
2. Material flow accounting (MFA)
3. Material intensity per service unit (MIPS)
4. Cumulative energy requirements analysis (CERA)
5. Environmental input/output analysis (IOA)
6. Environmental risk assessment (ERA)
7. Checklists for eco-design, life-cycle costing (LCC)
8. Total cost accounting (TCA)
9. Cost-benefit analysis (CBA)

Operational environmental tools

The most popular operational tools are:

1. Environmental management system (EMS)
2. Environmental audits
3. Environmental performance evaluation (EPE)
4. Environmental labeling
5. Eco-design
6. Green procurement
7. Total quality environmental management (TQEM)
8. Rating systems.

1.6.1 Rating systems

The sustainable performance of the building is the overall target and to this direction, several environmental and management tools have been developed which are known as green building assessment tools. Rating systems are environmental and management
tools that focus on the construction sector and target sustainability as well as economic and social benefits.

Most of the rating systems have as a base concept Life Cycle Analysis methodology and similarities with Environmental Management Systems (EMS). They also include the energy audit part and base their philosophy to other environmental issues such as water conservation, indoor air quality, materials’ selection, waste management, etc. They are basically scoring systems that evaluate new and existing buildings according to specific standards and guidelines for the environmental performance.

There are a number of criteria when trying to evaluate the rating systems. Some of them according to Fowler et. al. (2006) are:

• Measurability: Does the rating system use measurable characteristics to demonstrate the extent of sustainable design incorporated into the building?

• Applicability: Can the rating system be used on all of the types of buildings (commercial, domestic, offices, etc.)?

• Availability: Is the rating system easily implemented to other countries?

• Development: Based on which methodology is the rating system formed? Is it based on standards and legislation demands, on life cycle concept, on EMS philosophy, etc.?

• Usability: Is it practical and user-friendly? Has it practical guides with separated implementation information depending on building type?

• System Maturity: This criteria is relevant to the year of the system’s development, final revision, the number of buildings’ registered and certified.

• Technical Content: This is also an important parameter for rating systems and deals with the environmental aspects examined during the certification process.

• Communicability: Which is the reporting style of the certification at the end of the evaluation process? How exactly are the organizations and the public notified about a certified building?

• Cost: This criterion is very important for the user and includes data concerning the cost certification process of the building.
1.7 Subject of the Thesis

This thesis aims at presenting the relevance of the two better known Green Building assessment tools, BREEAM and LEED, for the Greek Building sector.

BREEAM and LEED are known to be the basis of many environmental tools that have been created in many countries. Greece has its own legislation regarding the building sector and recently has incorporated regulation regarding the Energy Performance of the newly built and existing buildings. The goal of this thesis is to describe both the Greek building sector and its environmental legislation, as well as BREEAM and LEED assessment tools. After the comparison between LEED and BREEAM, the ways that these tools are related to the Greek building sector are researched and presented.

1.8 Structure of the Thesis

The Thesis is divided into three parts.

The first part contains the abstract and the contents of the thesis. The second part is the main part and is consisted of 6 chapters. The third part is the bibliography that was studied for the completion of this thesis.

More specifically, the second part consists of 6 chapters. The first chapter presents the reasons that have led to the introduction of ‘sustainability’ in the building sector and furthermore the development of Green Building assessment tools, in order to achieve this sustainability and to bring social and economic benefits. It also includes the presentation of the subject of this thesis, its goal and its structure.

In chapter two, a literature review of all the books, papers, articles, etc. that have been studied in order to complete this thesis are presented.

Chapter three describes the history, features, assessment process and categories/sections of both LEED and BREEAM and concludes with the comparison between those two assessment tools.

In chapter four, the existing legislative framework concerning the Greek building sector and more specifically the one regarding the energy performance of buildings is presented.
In chapter five the relevance of LEED and BREEAM for the Greek building sector is researched. This is achieved by pointing out which issues, that are important for LEED and BREEAM, are included in the Greek legislation and the process of environmental certification of buildings and which are not. Two examples of Greek buildings that have been assessed with BREEAM and LEED are also presented.

Finally, in chapter six, the most important conclusions of this thesis are presented, as well as some suggestions for further research.
2 Literature review

2.1 Building impact on energy consumption and the attempts to lower the latter

The building sector is responsible for 40% of the total energy consumption on a national and European level. The final energy consumption in the European Union is as high as 1.168Mtoe or 2.4 toe /capita (Giama, 2009). Residential buildings consume 67% of the total energy consumed on the building sector (M. Vijayalakshmi et al., 2006).

Buildings have a huge impact on the environment from the beginning of their life till the end of it (from cradle to grave) through the processes of extraction and processing of materials, transportation, construction of the building, its maintenance and use and finally the demolition process. Energy, materials, water and land are all consumed in the construction and operation of buildings and infrastructure (T. Mehzer, 2005). The construction of buildings consumes 40% of the stone, sand and gravel, 25% of the virgin wood, 40% of the energy and 16% of the water globally consumed every year (Arena and de Rosa, 2003).

Thus, the main target today is to minimize the environmental impact of constructions as much as possible. Energy saving through improved energy efficiency is promoted since energy efficient buildings consume relatively less energy for maintaining a comfortable indoor environment (Vijayalakshmi et al., 2006). The concept of sustainability is promoted. Sustainable or green or ecological building incorporates a variety of aspects and perspectives. Principles and technologies have been developing for over two decades now with various bodies (governmental, academic, professional, NGOs) promoting green building. However many consider the cost as an obstacle to sustainability. This is not the case since high investments into energetic improvements generally pay off after a certain period of time (Dirlich, 2011).
2.2 Green Building as the attempt to address these issues in a comprehensive manner

With the increasing awareness of sustainable development in the construction industry, implementation of an energy rating procedure to assess buildings is needed (Roderick et al., 2008).

The continuously growing demand for building projects that use environmentally friendly and energy-efficient materials has introduced a green movement in the construction industry. One of the most popular ways to save energy and of course money is by using ‘Green Building’ techniques in new or existing buildings.

Green building represents a great change in the way we understand, design and construct today. Its goal is to improve current design and construction practices and standards so that the buildings we build today will last longer, be more efficient, cost less to operate, and contribute to healthier living and working environments for occupants, thereby helping to promote wellbeing and increase productivity. Green building is also about increasing the efficiency with which buildings and their sites utilize energy, water, and materials, protect natural resources, and improve the built environment (Kubba, 2010).

In order to satisfy this demand for evaluation and management of building environmental performance several tools and methodologies have been developed and implemented in building construction aiming at sustainable performance. ‘Rating systems are environmental and management tools focusing on the construction sector and aiming at sustainability as well as at economic and social benefits’. Sustainable design guidelines are a way to include environmental issues in the design, construction and operation of buildings (Papadopoulos, Giama, 2007).
2.3 Various organizations and assessment tools - LEED, BREEAM, Green Star etc. - when, where, how

Many countries and international organizations have developed rating systems for sustainable construction. Currently, a number of different rating systems are used to rate the environmental performance of buildings. United Kingdom's BREEAM and the United States’ LEED are two of the better known and widely used (Azhar et al., 2010).

BREEAM is the most widely used rating system in Europe and the older one (launched in 1990 in the United Kingdom). It evaluates the building’s performance in eight categories by awarding points for each one. The categories are: management, health and wellbeing, energy, transport, water, materials, land use and ecology, and pollution. BREEAM covers a range of building types including: offices, homes, industrial units, retail units, and schools.

LEED was developed in the United States in 1998 and it promotes a whole-building approach to sustainability by measuring performance in six categories in order to achieve human and environmental health. These categories are: Sustainable site development, Water efficiency, Energy and atmosphere, Materials and resources, Indoor environmental quality and Innovation and design process. LEED can be applied to several building and project types such as: New Commercial Construction and Major Renovation projects, Existing Building Operations and Maintenance, Commercial Interiors projects, Core and Shell Development projects, Homes, Neighborhood Development, Guidelines for Multiple Buildings and On-Campus Building Projects, Schools and Healthcare (Papadopoulos, Giama, 2007).

“Green Star is the most followed voluntary building environmental assessment scheme in Australia”. It was developed to taking into account the needs of buildings in hot climates, where cooling systems and solar shading are of significant importance. It has also been adopted in New Zealand and South Africa. Green Star uses the credit rating system based on a number of points allocated in order to determine the total scoring and thus the level of certification. The credits are organized in the following aspects of the building and process: management, indoor environmental quality, energy, transport, water, materials, land use and ecology, emissions, and innovation (Roderick et al., 2008).
CASBEE is the rating system used in Japan, available abroad with measurable evaluation characteristics during the certification process. CASBEE was first launched in 2004 by the Japan Sustainable Building Consortium. The methodology used to calculate the score is called BEE (Building Environmental Efficiency) that is divided between environmental load reduction and building quality performance. There are 4 different versions of CASBEE: CASBEE for Pre-Design, CASBEE for New Construction, CASBEE for Existing Buildings and CASBEE for Renovation (Saunders, 2008).

2.4 LEED vs. BREEAM

Dirlich (2011) compared BREEAM with LEED. He states that BREEAM is one of the best rating systems and has functioned as the basis of several other systems used in other countries. LEED on the other hand offers a positive impact on public health and the environment and helps create a sustainable community through the Green Design process, but is identified as the most ‘cost intensive’ one.

The comparison process is focused on the criteria and the indicators of each assessment scheme. It concludes that the examined schemes are relatively similar and cover more or less the same categories, but the weighting of these categories causes different results for the same building. More specifically according to Dirlich, LEED assesses buildings more favorably than BREEAM meaning that it is easier to achieve high rating in LEED. However it concludes that a holistic approach to the building’s sustainability is not found yet in these systems and social, economic and regional criteria should also be taken into account. Thus, a scheme should be created to be used globally for assessing buildings in order to be able to ensure comparability.

The “inbuilt” report (2010) examines the history, facts and features of BREEAM and LEED and presents an overview of BREEAM 2008, credits and weightings and of LEED 2009. A detailed credit comparison between the two schemes in all the categories follows and finally the similar points and the conclusions about each scheme’s benefits in a UK context are presented.

According to the report there are many elements common to both the assessment schemes. On the other hand, it considers that to score well under LEED is easier than
under BREEAM certification. It describes LEED’s strong points to be: occupant comfort, internal pollution issues, heat island effects and points out that it focuses on countries which use mechanical ventilation and air conditioning and where existing infrastructure promotes the use of cars. It considers BREEAM strengths to be on pedestrian and cyclist safety, with much higher targets for cyclist spaces and says that it is also stronger than LEED on the water and acoustics criteria.

However it points out that LEED has been accused of not basing credits on scientific research unlike BREEAM which both has a more scientific basis for the research and covers more of the social aspects of sustainability. On the other hand BREEAM suffers from lack of transparency which is a great advantage of LEED.

The Roderick et al. (2008) paper focuses on the investigation of energy performance assessment for new office buildings within the LEED, BREEAM and Green Star schemes. Through a case study building, an attempt is made to make clear how building energy performance is assessed and therefore awarded with energy credits under the LEED, BREEAM and Green Star schemes.

The results of this paper show that the energy performance of the building and the rating obtained are strongly dependent on the assessment scheme used. More specifically the case study office building received a low energy rating in BREEAM and it failed to be certified in LEED. According to the authors, since the three schemes are based on different energy assessment methods and performance criteria, it should not come as a surprise that the energy rating results are different.

The Lee and Burnett (2007) paper describes how the baseline buildings, performance criteria and the credit scales of the three schemes compare with each other and forms a good basis for future benchmarking of energy assessment schemes across countries.

According to the paper, the three schemes have significant differences in scope and assessment criteria but they all include features that aim at the improvement of the energy performance.

The performance criteria of the schemes are compared and BREEAM seems to be the one that sets a more demanding reduction target to require zero carbon emission meaning that more credits are awarded for an increase in performance level.
However it concludes that it is much more difficult to score energy credits under BREEAM and that those buildings that managed to score excellent energy performance under BREEAM and LEED belong to the top 5% in the market.

Thomas Saunders (2008) in his report examines the most commonly used assessment schemes (including LEED), and compares them to the UK benchmark BREEAM. Their description involves their assessment process, the scoring and weightings and their development.

The results show that there are great variations between the systems for the same grade. For example buildings designed to achieve high LEED scores in the UK will generally not score as well when assessed for BREEAM and the other way around buildings which achieve a medium score against BREEAM, in the UK, are likely to achieve higher scores against LEED. Saunders proceeds to conclude that none of these systems travel well and that there may always be differences between the relative standards set by each system even if there is more transparency and more comparability. However he states that competition is positive as it will ‘push’ the standards to improvements.

The major differences have been highlighted and one of their key differences is the use of life cycle analysis.

The comparison of this study was decided to be conducted by trying to find how well a UK building might score against BREEAM if it was designed to meet the criteria of the other schemes. When it comes to LEED, if designed to satisfy its criteria, the maximum rating that a UK building could achieve was found to be ‘Good, but if designed to satisfy BREEAM, it was found to achieve a rating of ‘gold’ for LEED. According to Saunders, the comparison shows that it is tougher to meet the highest rating in BREEAM than it is to meet the requirements of the alternative schemes when building in the UK. If a building is designed to meet the highest LEED rating it will only achieve a BREEAM rating which is the second or third highest since the comparison shows that BREEAM ratings are generally higher in terms of environmental performance than the equivalent ratings of the alternative schemes. The final conclusion is that since all the schemes are affected by regional factors and don’t work well outside their native country, a new more international scheme should be created and used promoting comparability and transparency.
Sleeuw (2011) compares the most widely used environmental assessments, BREEAM and LEED, and assesses whether there are similarities between their rating classifications. According to the report, both methods have specific rating schemes and systems for different building uses and they both rely on existing building regulations and other third party standards to set performance criteria, but they also have significant differences in their detailed methodologies, scope and emphasis of assessment, metrics, and certification processes.

The author here points out the results by Saunders (2008) and Lee and Burnett (2007) who have found that BREEAM is much tougher than LEED to score points and that both schemes do not travel well if used in other countries.

He then proceeds to highlight the strengths of both schemes and concludes that direct comparison is not straightforward. If common metrics and performance standards can be agreed, then both methods may be considered equivalent. Until then, LEED is thought to be of less value as a certificate for buildings in the UK.

Papadopoulos and Giama (2007) focus their paper on the analysis of the rating systems, their comparison and their implementation regarding the environmental performance of the buildings. The criteria for this evaluation are set, and LEED and BREEAM are implemented to an office building in Greece in order to calculate the building’s performance.

The BREEAM evaluation process concluded that at its present state, the sample building is not adequate enough for BREEAM evaluation. On the other hand, according to LEED the building could be certified.

Therefore, once again the conclusion drawn is that BREEAM is much tougher than LEED.

James Parker (2009) published an article that focuses on the strong and weak points of BREEAM and LEED as well as on identifying their differences.

According to the author BREEAM has been the dominant assessment method but LEED has appeared to be an accounted competitor.
The main difference stated here between the two methods is the process of certification. BREEAM has trained assessors while LEED does not require training although there is a credit available if an accredited professional (AP) is used.

When it comes to the comparison, according to Parker, BREEAM delivers a higher rating for the same building in both the US and the UK.

The opinion of Eszter Gulacsy, a sustainability consultant from MTT/Sustain is stated, and she believes LEED is simpler in its approach, while BREEAM is more academic and strict. "While BREEAM is more relevant in the UK as it uses UK policies, LEED can sit alongside as part of a global corporate policy," she says.

When it comes to a more global assessment scheme, the author claims that it would be something very difficult to achieve, however BREEAM seems to be taking steps to that direction with BREEAM Gulf and BREEAM international and seems to be more adaptable to local contexts. On the other hand, LEED is fixed to the ASHRAE standards and the ‘US way of thinking’ and does not have the same level of adaptability.

The conclusion drawn is that despite their differences, both schemes seem to coexist and even cooperate well with each other.

Dave Cheshire (2011) published an article that examines whether LEED has started to gain ground over the dominant UK scheme BREEAM. It does so by pointing out their strengths and weaknesses and by comparing the two methods.

According to the article, even though there seems to be an increase on the market for LEED inquiries, BREEAM still is a more mature scheme.

One of LEED's greatest strengths globally is that it has been adapted to suit the US market. But this strength is also a weakness in challenging BREEAM's position in the UK, states Dave Chesire. The fundamental weakness of LEED in the UK is that its standards correspond to the US market. LEED has become strong because it has been intensively marketed, but BREEAM has grown organically.

“BREEAM's key advantage in the UK is that it uses and builds on legislation and standards to award credits”.

When it comes to the comparison the author states that it is very difficult to compare the two schemes but there are some evident differences. In general LEED is simpler and
BREEAM is stricter and sets more absolute targets, thus ‘pushing’ to improve environmental performance.

However the article concludes that both schemes need to improve and they need to consider how the building will operate in reality. Steps are taken to this direction by both schemes. Finally, according to the article, BREEAM still is dominant especially in the UK market but LEED seems to be gaining ground, especially by multinationals, since it is more globally recognized. But at the end, both schemes learn from each other and improve through their competition.
3 Green Building assessment tools overview

Green building assessment tools, as was mentioned previously, are environmental and management tools that focus on the construction sector and target sustainability as well as economic and social benefits. In many countries such tools have been created and implemented for years now. This dissertation is focusing on the two most well-known ones, the Leadership in Energy and Environmental Design (LEED) and the Building Research Establishment’s Environmental Assessment Method (BREEAM).

3.1 The Leadership in Energy and Environmental Design (LEED)

3.1.1 History of LEED

In 1993 the U.S. Green Building Council (USGB), a national non-profit membership body, was formatted and it immediately decided to create a system to define and measure “Green Buildings”. A committee, which included architects, realtors, a building owner, a lawyer, an environmentalist and industry representatives, was responsible for the development of this system. In August 1998 the first LEED version 1.0 was launched.

The rating system is now called LEED Green Building Rating System for New Construction & Major Renovations (Version 2.2) or LEED for New Construction (LEED-NC). Since 27 April of 2009, LEED 2009 replaced LEED 2.2 by introducing some small corrections. This dissertation describes and deals with LEED-NC, although the differences of the two versions will be mentioned (LEED for New construction and major renovation, v2.2 reference guide, 2006).

The LEED product portfolio is expanded, as shown in Figure 1, to many areas.
3.1.2 Features of LEED

LEED is a voluntary building rating system that evaluates the building's environmental performance and sets the standards that constitute a “Green building”.

It provides a whole building approach by measuring sustainability in six categories:

- Sustainable site development
- Water efficiency
- Energy and atmosphere
- Materials and resources
- Indoor environmental quality
- Innovation and design process

LEED is a credit-based assessment tool. Based on the credits earned for each one of the categories mentioned above, a different level of certification is awarded. Table 3.1 shows the points required in order to achieve certification for each level (inbuilt report, 2010).
Table 3.1: LEED certification points (source: inbuilt report, 2010)

<table>
<thead>
<tr>
<th>LEED rating</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certified</td>
<td>40-49</td>
</tr>
<tr>
<td>Silver</td>
<td>50-59</td>
</tr>
<tr>
<td>Gold</td>
<td>60-79</td>
</tr>
<tr>
<td>Platinum</td>
<td>80 points and above</td>
</tr>
</tbody>
</table>

The points of Table 3.1 correspond to LEED 2009. The maximum amount of points that can be earned is 110. The 100 points are base points, 6 are possible innovation in design points, and 4 are regional priority points. The LEED 2.2 version has a maximum of 69 points. The larger amount of points in LEED 2009 is the main difference of the two versions and is due to the change of the numerical weightings of each category.

Table 3.2 shows the comparison of the two versions. The percentage column shows the different distribution of the LEED classifications (Murphy, 2009).

Table 3.2: Comparison of LEED 2.2 and LEED 2009 (source: Murphy, 2009).
It should be pointed out that LEED has a number of prerequisites, meaning there are certain credits that are mandatory for all ratings.

3.1.3 Assessment process

In order to achieve certification a project should first of all satisfy all the prerequisites and secondly it should be able to earn the minimum sum of points required for a specific rating. The application process has the option of being split into two phases.

The first phase is the design phase, which is optional. At this point after an application and a fee is sent to the USGBC, the project team is informed about the likelihood of achieving certain points at the end of the whole process. No certificate is awarded at this phase.

The second phase is the construction phase review. After the completion of the construction, the documentation is submitted to the USGBC in order to decide the number of points that are awarded. The credits of the design phase should at this point be verified. After the submission of the application and of the fee, the USGBC reviews the application and decides whether to issue a certificate or not. If a rating level is achieved, a formal letter of certification and a plaque are awarded.

3.1.4 LEED’s categories and credits

Sustainable Sites (SS)

The location of a building should be carefully chosen since its impact on the environment is significant. Integrating building location in the sustainable design helps limit the environmental impacts and enhance the health of the surrounding community.
**SS Prerequisite 1: Construction Activity Pollution Prevention**

Prevent pollution bourn from activities during construction, by implementing an Erosion and Sedimentation Control (ESC) plan. This is a prerequisite for the SS category.

**SS Credit 1: Site Selection**

Avoid selecting a site for a project that is considered inappropriate, such as prime farmland or a land inhabited by endangered species. Choose a site keeping in mind the reduction of the environmental impact from the location of the building. One point is earned for this credit.

**SS Credit 2: Development Density & Community Connectivity**

Choose the site keeping in mind the proximity to urban areas as well as the access to public transport in order to preserve virgin land. One point is earned for this credit.

**SS Credit 3: Brownfield Redevelopment**

Select a site that is either contaminated or defined as brownfield and restore it rather than using ‘healthy’ undeveloped land. One point is earned for this credit.

**SS Credit 4.1: Alternative Transportation: Public Transportation Access**

Select a site with access to public transportation in order to reduce pollution from the use of automobiles. One point is earned for this credit.

**SS Credit 4.2: Alternative Transportation: Bicycle Storage & Changing Rooms**

Design bicycle racks and changing rooms for the building, facilitating the use of bicycles and reducing the pollution from automobile use. One point is earned for this credit.
SS Credit 4.3: Alternative Transportation: Low Emitting & Fuel Efficient Vehicle

Provide low emitting and fuel efficient vehicles for a certain amount of the occupants as well as parking spaces and refueling stations for these vehicles. This way their use is promoted and the reduction of pollution from automobile use is achieved. One point is earned for this credit.

SS Credit 4.4: Alternative Transportation: Parking Capacity

Reduce the use of single occupancy vehicles in order to reduce pollution from automobiles. One point is earned for this credit.

SS Credit 5.1: Site Development: Protect or Restore Habitat

Restore damaged areas and site the building appropriately, in order to avoid disruption of the ecosystems or of natural areas. One point is earned for this credit.

SS Credit 5.2: Site Development: Maximize Open Space

Develop the site and design the building by maximizing open space areas, thus promoting biodiversity (for urban areas vegetated roofs and pedestrian oriented hardscape areas can be used). One point is earned for this credit.

SS Credit 6.1: Stormwater Design: Quantity Control

Minimize impervious surfaces, increase infiltration and reuse stormwater in order to control the quantity of natural water. One point is earned for this credit.

SS Credit 6.2: Stormwater Design: Quality Control

Reduce impervious areas, increase infiltration and treat storm water runoff, in order to avoid pollutants. One point is earned for this credit.
SS Credit 7.1: Heat Island Effect: Non-Roof

SS Credit 7.2: Heat Island Effect: Roof

Reduce urban heat island effect and its impacts on human life and microclimate by shading surfaces, using vegetated roofs and high reflectance materials. One point is earned for each one of these credits.

SS Credit 8: Light Pollution Reduction

Reduce light pollution by maintaining certain light levels and through the appropriate design for interior and exterior lighting. One point is earned for this credit.

Water Efficiency (WE)

The building industry uses large volumes of water which means that maintenance and lifecycle costs for the building operations increase and so do the consumer costs. Water conservation strategies are very important and that is why they are included in the sustainable design process.

WE Credit 1.1: Water Efficient Landscaping: Reduce by 50%

Reduce the use of potable or other natural water for irrigation. One point is earned for this credit.

WE Credit 1.2: Water Efficient Landscaping: No Potable Water Use or No Irrigation

Eliminate the use of potable or other natural water for irrigation. Use only rainwater or greywater if needed. One point is earned for this credit in addition to WE Credit 1.1.
WE Credit 2: Innovative Wastewater Technologies

Reduce wastewater generated on-site and consider wastewater treatment systems in order to reduce potable water demand. One point is earned for this credit.

WE Credit 3.1: Water Use Reduction: 20% Reduction

WE Credit 3.2: Water Use Reduction: 30% Reduction

Use efficient technology to reduce potable water demand and increase water efficiency of the building. One point is earned for the first credit and one point is earned for the second credit for an additional 10%.

Energy & Atmosphere (EA)

The building sector is responsible for the consumption of great amounts of energy which also has as a result the burdening of the atmosphere with high amounts of CO₂. It is thus very important to deal with these issues as it is an effort to reduce the energy consumption, by increasing the energy efficiency and the use of renewable energy sources.

EA Prerequisite 1: Fundamental Commissioning of the Building Energy Systems

Verification that the energy related systems like HVAC and Refrigeration, lighting, DHW and RES, are installed and function as they are required to, according to the design. This is a prerequisite for the EA category.

EA Prerequisite 2: Minimum Energy Performance Required

Design the building in such a way that the minimum level of energy efficiency is reached (maximize performance by proper design of HVAC, lighting, DHW systems, RES and building envelope). This is a prerequisite for the EA category.
**EA Prerequisite 3: Fundamental Refrigerant Management**

Use HVAC equipment with no CFC refrigerants in order to reduce ozone depletion. This is a prerequisite for the EA category.

**EA Credit 1: Optimize Energy Performance**

Design the energy systems and the envelope of the building in order to achieve higher levels of energy performance than the minimum required in the prerequisite, thus reducing the environmental impacts due to the energy use. It is possible to earn one to ten points (1-10) for this credit.

**EA Credit 2: On-Site Renewable Energy**

Design the project using on-site Renewable Energy self-supply aiming to the reduction of the environmental impacts due to fossil fuel use. One to three (1-3) points may be earned for this credit, depending on the percentage of renewable energy used.

More specifically:

<table>
<thead>
<tr>
<th>% Renewable Energy</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5%</td>
<td>1</td>
</tr>
<tr>
<td>7.5%</td>
<td>2</td>
</tr>
<tr>
<td>12.5%</td>
<td>3</td>
</tr>
</tbody>
</table>

**EA Credit 3: Enhanced Commissioning**

Commissioning process begins at an early stage, the design stage, up until the completion of the project. One point is earned for this credit.
**EA Credit 4: Enhanced Refrigerant Management**

In order to reduce ozone depletion and avoid contributions to global warming, use no refrigerants, or use ones that don’t contribute to these effects. One point is earned for this credit.

**EA Credit 5: Measurement & Verification**

Evaluate the building and its energy systems’ performance and measure energy use with metering equipment, in order to verify that the actual performance is as it was predicted. One point is earned for this credit.

**EA Credit 6: Green Power**

Promote the use of RES for providing part of the building’s electricity, by signing an at least 2-year RES-contract. One point is earned for this credit.

**Materials & Resources (MR)**

The choice of the building materials is very important for the sustainable design. The processes of extraction, transportation and disposal can impact the environment. In order to minimize this impact there are strategies that can be applied and that promote the sustainable design concept.

**MR Prerequisite 1: Storage & Collection of Recyclables**

Provide areas for collection and storage of recycling materials, in order to reduce the amount of waste generated from the building’s occupants. This is a prerequisite for the MR category.
**MR Credit 1.1: Building Reuse: Maintain 75% of Existing Walls, Floors & Roof**

Reuse 75% of existing building structure and envelope in order to reduce waste and environmental impacts and to conserve resources. One point is earned for this credit.

**MR Credit 1.2: Building Reuse - Maintain 95% of Existing Walls, Floors & Roof**

Same as the MR Credit 1.1, with an additional 20% of reuse. One point is earned for this credit in addition to MR Credit 1.1.

**MR Credit 1.3: Building Reuse: Maintain 50% of Interior Non-Structural Elements**

Reuse of interior non-structural elements in at least 50% of the building, in order to reduce waste and environmental impacts and to conserve resources. One point is earned for this credit.

**MR Credit 2.1: Construction Waste Management: Divert 50% from Disposal**

Implement a Construction Waste Management plan to divert at least 50% of construction and demolition waste from disposal in landfills or incinerators, in order to reduce environmental impacts. One point is earned for this credit.

**MR Credit 2.2: Construction Waste Management: Divert 75% from Disposal**

Same as the MR Credit 2.1, with an additional 25% of diversion. One point is earned for this credit in addition to MR Credit 2.1.

**MR Credit 3.1: Materials Reuse: 5%**

Consider reusing building materials that are equal to at least 5% of the total value of the materials used for the project. The goal is to reduce environmental impacts connected to
the process of extraction of virgin resources and in order to reduce waste. One point is earned for this credit.

**MR Credit 3.2: Materials Reuse: 10%**

Same as MR credit 3.1, with an additional 5% of reuse. One point is earned for this credit in addition to MR Credit 3.1.

**MR Credit 4.1: Recycled Content: 10% (post-consumer + ½ pre-consumer)**

Consider using recycled content materials, such that the post-consumer plus ½ of pre-consumer materials are equal to at least 10% of the total value of the materials used in the project. The goal is to reduce impacts due to extraction and processing of materials. One point is earned for this credit.

**MR Credit 4.2: Recycled Content: 20% (post-consumer + ½ pre-consumer)**

Same as MR Credit 4.2, with an additional 10% of use of recycled content materials. One point is earned for this credit in addition to MR Credit 4.1.

**MR Credit 5.1: Regional Materials: 10% Extracted, Processed & Manufactured Regionally**

Use materials that have been extracted, processed and manufactured regionally (within 500 miles of the site), for at least 10% of the total value of materials used for the project. The goal is to increase demand for regional materials and products and to reduce impacts due to transportation. One point is earned for this credit.
**MR Credit 5.2: Regional Materials: 20% Extracted, Processed & Manufactured Regionally**

Same as MR Credit 5.1, with an additional 10% of use of regional materials. One point is earned for this credit in addition to MR Credit 5.1.

**MR Credit 6: Rapidly Renewable Materials**

Consider using rapidly renewable materials, in order to reduce the use and avoid depletion of finite materials. One point is earned for this credit.

**MR Credit 7: Certified Wood**

For the wood components of the building use certified wood (according to the Forest Stewardship Council) in order to promote proper forest management. One point is earned for this credit.

**Indoor Environmental Quality (EQ)**

To enhance indoor environmental quality is important since it contributes to the comfort and well-being of the occupants and it is also known to increase the levels of productivity. It is therefore evident why it is important to incorporate it to the sustainable design.

**EQ Prerequisite 1: Minimum Indoor Air Quality (IAQ) Performance**

Establish the comfort and well-being of the occupants by accomplishing a minimum IAQ performance. This is a prerequisite for the EQ category.

**EQ Prerequisite 2: Environmental Tobacco Smoke (ETS) Control**

Prohibit smoking or control the ventilation in designated smoking areas in order to minimize the effects caused on building occupants and surfaces from the Tobacco Smoke. This is a prerequisite for the EQ category.
EQ Credit 1: Outdoor Air Delivery Monitoring

Monitor ventilation system’s performance in order to maintain occupant comfort and well-being. One point is earned for this credit.

EQ Credit 2: Increased Ventilation

Increase outdoor air ventilation in order to help improve air quality, thus improving the comfort, well-being and productivity of the occupants. One point is earned for this credit.

EQ Credit 3.1: Construction IAQ Management Plan: During Construction

Implement IAQ Management plan during the construction phase in order to protect the comfort and well-being of the workers and the occupants. One point is earned for this credit.

EQ Credit 3.2: Construction IAQ Management Plan: Before Occupancy

Before occupancy test the IAQ performance of the building, in order to protect the comfort and well-being of the workers and the occupants. One point is earned for this credit in addition to EQ Credit 3.1.

EQ Credit 4.1: Low-Emitting Materials: Adhesives & Sealants

EQ Credit 4.2: Low-Emitting Materials: Paints & Coatings

EQ Credit 4.3: Low-Emitting Materials: Carpet Systems

EQ Credit 4.4: Low-Emitting Materials: Composite Wood & Agrifiber Products
For EQ Credit 4.1- 4.4, use low emitting materials (according to standards), in order to reduce the amount of indoor air contaminants that can harm the health, comfort and well-being of the occupants and the installers as well. One point is earned for each one of these credits.

*EQ Credit 5: Indoor Chemical & Pollutant Source Control*

Apply design that minimizes and controls the entrance of pollutants to the building, in order to prevent the exposure of the occupants to such contaminants. One point is earned for this credit.

*EQ Credit 6.1: Controllability of Systems: Lighting*

Design the overall lighting system by integrating occupant controls for lighting. This promotes the comfort, well-being and productivity of the occupants, as lighting can be adjusted to suit their needs. One point is earned for this credit.

*EQ Credit 6.2: Controllability of Systems: Thermal Comfort*

Design the building with comfort controls in order to ensure the comfort, well-being and productivity of the occupants, as they can adjust the system to suit their individual needs. One point is earned for this credit.

*EQ Credit 7.1: Thermal Comfort: Design*

Design HVAC systems and building envelope according to ASHRAE Standard for Thermal Comfort Conditions for Human Occupancy, in order to ensure that the comfort, well-being and productivity of the occupants are kept. One point is earned for this credit.
**EQ Credit 7.2: Thermal Comfort: Verification**

Document the building’s thermal comfort over time and develop a plan for corrections if the desired levels are not reached. One point is earned for this credit.

**EQ Credit 8.1: Daylight & Views: Daylight 75% of Spaces**

**EQ Credit 8.2: Daylight & Views: Views for 90% of Spaces**

Design the building trying to maximize the interior daylighting and the view, thus providing the occupants with a more comfortable living environment. One point is earned for each of these credits.

**Innovation & Design Process (ID)**

**ID Credit 1–1.4: Innovation in Design**

Provide designer teams the freedom to propose new approaches to some categories and the opportunity to earn more points for exceptional performance. One to four (1-4) points are earned for this credit.

**ID Credit 2: LEED Accredited Professional**

Promote the use of a LEED Accredited Professional (AP), to help with the design process as well as the application process. One point is earned for this credit.

All of the above mentioned credit points correspond to LEED-NC v2.2. (LEED for new construction, version2.2, 2005). As it was mentioned before, the weightings have changed for the LEED 2009 version. The changes are shown in Table 3.3.
Table 3.3: Comparison of the weightings per credits between LEED 2.0 and LEED 2009 (source: inbuilt report, 2010)

<table>
<thead>
<tr>
<th>Credit</th>
<th>LEED 2.0</th>
<th>LEED 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSP1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SS1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SS2</td>
<td>1</td>
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<td>SS3</td>
<td>1</td>
<td>1</td>
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<td>6</td>
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</tr>
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</tr>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>IEQ4.3</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>IEQ4.4</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>IEQ5</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>IEQ6.1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>IEQ6.2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>IEQ7.1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>IEQ7.2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>IEQ8.1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>IEQ8.2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>ID1</td>
<td>4</td>
<td>1-5</td>
</tr>
<tr>
<td>ID2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>RP</td>
<td>n/a</td>
<td>1-4</td>
</tr>
<tr>
<td>69</td>
<td>110</td>
<td></td>
</tr>
</tbody>
</table>
3.2 The Building Research Establishment Environmental Assessment Method (BREEAM)

3.2.1 History of BREEAM

BREEAM was conceived in the UK by the Building Research Establishment (BRE), which was at the time a government funded research body. It was first launched in 1990 and its first version was used in order to assess the environmental performance of offices. Over 200,000 projects have been certified until now.

The latest version of the scheme is BREEAM 2011 New Construction.

3.2.2 Features of BREEAM

BREEAM aims at achieving a decrease in the environmental impacts of a building and at increasing its environmental benefits. An environmental rating is calculated by awarding points for meeting the requirements of certain categories/sections:

- Management
- Health and Wellbeing
- Energy
- Transport
- Water
- Materials
- Land use and Ecology
- Pollution
- Innovation

Each one of these categories is weighted differently according to its environmental importance. Table 3.4 shows the weightings of each BREEAM section.
Table 3.4: BREEAM environmental section weightings (source: BREEAM New Construction, 2011)

<table>
<thead>
<tr>
<th>Environmental section</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management</td>
<td>12%</td>
</tr>
<tr>
<td>Health &amp; Wellbeing</td>
<td>15%</td>
</tr>
<tr>
<td>Energy</td>
<td>19%</td>
</tr>
<tr>
<td>Transport</td>
<td>8%</td>
</tr>
<tr>
<td>Water</td>
<td>6%</td>
</tr>
<tr>
<td>Materials</td>
<td>12.5%</td>
</tr>
<tr>
<td>Waste</td>
<td>7.5%</td>
</tr>
<tr>
<td>Land Use &amp; Ecology</td>
<td>10%</td>
</tr>
<tr>
<td>Pollution</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
<tr>
<td>Innovation (additional)</td>
<td>10%</td>
</tr>
</tbody>
</table>

By multiplying the percentage of credits earned for one section to its weighting factor, the section score is calculated. The sum of all the scores for each section is the BREEAM score of a project. The BREEAM rating is then awarded. The percentages required to achieve each level of certification are shown in Table 3.5.

Table 3.5: BREEAM rating benchmarks (source: BREEAM New Construction, 2011)

<table>
<thead>
<tr>
<th>BREEAM Rating</th>
<th>% score</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTSTANDING</td>
<td>85</td>
</tr>
<tr>
<td>EXCELLENT</td>
<td>70</td>
</tr>
<tr>
<td>VERY GOOD</td>
<td>55</td>
</tr>
<tr>
<td>GOOD</td>
<td>45</td>
</tr>
<tr>
<td>PASS</td>
<td>30</td>
</tr>
<tr>
<td>UNCLASSIFIED</td>
<td>&lt;30</td>
</tr>
</tbody>
</table>
At this point it should be pointed out that in order to achieve a BREEAM rating, other than achieving a certain score, there are certain minimum standards that should be reached. BREEAM sets this rule to ensure high levels of performance against basic environmental issues. These minimum BREEAM standards by rating level are shown in Table 3.6.

Table 3.6: Minimum BREEAM standards by rating level (source: BREEAM New Construction, 2011)

<table>
<thead>
<tr>
<th>BREEAM issue</th>
<th>PASS</th>
<th>GOOD</th>
<th>VERY GOOD</th>
<th>EXCELLENT</th>
<th>OUTSTANDING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man 01: Sustainable procurement</td>
<td>One credit</td>
<td>One credit</td>
<td>One credit</td>
<td>One credit</td>
<td>Two credits</td>
</tr>
<tr>
<td>Man 02: Responsible construction practices</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>One credit</td>
<td>Two credits</td>
</tr>
<tr>
<td>Man 04: Stakeholder participation</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>One credit (Building user information)</td>
<td>One credit (Building user information)</td>
</tr>
<tr>
<td>Hea 01: Visual comfort</td>
<td>Criterion 1 only</td>
<td>Criterion 1 only</td>
<td>Criterion 1 only</td>
<td>Criterion 1 only</td>
<td>Criterion 1 only</td>
</tr>
<tr>
<td>Hea 04: Water quality</td>
<td>Criterion 1 only</td>
<td>Criterion 1 only</td>
<td>Criterion 1 only</td>
<td>Criterion 1 only</td>
<td>Criterion 1 only</td>
</tr>
<tr>
<td>Ene 01: Reduction of CO₂ emissions</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>Six credits</td>
<td>Ten credits</td>
</tr>
<tr>
<td>Ene 02: Energy monitoring</td>
<td>None</td>
<td>None</td>
<td>One credit (First sub-metering credit)</td>
<td>One credit (First sub-metering credit)</td>
<td>One credit (First sub-metering credit)</td>
</tr>
<tr>
<td>Ene 04: Low or zero carbon technologies</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>One credit</td>
<td>One credit</td>
</tr>
<tr>
<td>Wat 01: Water consumption</td>
<td>None</td>
<td>One credit</td>
<td>One credit</td>
<td>One credit</td>
<td>Two credits</td>
</tr>
<tr>
<td>Wat 02: Water monitoring</td>
<td>None</td>
<td>Criterion 1 only</td>
<td>Criterion 1 only</td>
<td>Criterion 1 only</td>
<td>Criterion 1 only</td>
</tr>
<tr>
<td>Mat 03: Responsible Sourcing</td>
<td>Criterion 3 only</td>
<td>Criterion 3 only</td>
<td>Criterion 3 only</td>
<td>Criterion 3 only</td>
<td>Criterion 3 only</td>
</tr>
<tr>
<td>Wst 01: Construction waste management</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>One credit</td>
</tr>
</tbody>
</table>
As it is shown before, in Table 3.4, there is an extra 1-10% awarded for innovation. BREEAM chooses these “innovation credits” as a way to support new innovative technologies, design and construction methods. These points are awarded besides the BREEAM rating and can be awarded regardless of the level achieved. (BREEAM New Construction, 2011)

### 3.2.3 Assessment process

The BREEAM assessment process is carried out by licensed assessors who are trained by the BRE. The assessor’s responsibility is to gather the necessary data and file a report stating the overall score and rating of the project. There are two possible stages that the process can be divided to (Saunders, 2008).

The first one is the design stage. At this phase the building’s performance is calculated based only on the detailed designs. The calculated certification is not the final one.

The second stage is the post-construction stage. Here, the assessment is carried out after the completion of the building’s construction and the final performance and rating is calculated (BREEAM Assessor Manual, 2008).

BRE reviews the report and if it the rating is confirmed, then a BREEAM certificate is sent to the client.
3.2.4 BREEAM’s environmental sections and credits

Management (Man)

Man 01 Sustainable procurement

This BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are eight.

The aim of this issue is to ensure that every action, from the design stage to the construction and handover, is executed as it was expected to. This issue also includes commissioning for some period after the building has been occupied, in order to make sure its performance is as required.

This issue and the credits are split into three parts:
- Project brief and design (4 credits)
- Construction and handover (2 credits)
- Aftercare (2 credits)

Man 02 Responsible construction practices

This BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are two.

The aim of this issue is to promote the responsible management of the construction site, in order to avoid environmental and social impacts.

Man 03 Construction site impacts

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are five.

Credits are divided into five parts, each one worth of one credit. These are:
- Energy consumption
- Water consumption
- Transport of construction materials and waste
- Timber procurement
- Construction site management.

For all of the above categories, the aim of this issue is to ensure through monitoring and reporting, that the construction site is managed responsibly, in terms of resource use, energy consumption and pollution.

**Man 04 Stakeholder participation**

Only a part of this BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are four.

The aim of this issue is to provide building users and occupants with all the required information and include them into the decision process, in order to deliver a functional building for everyone’s needs.

This issue is split into four parts:
- Consultation (1 credit)
- Inclusive and accessible design (1 credit)
- Building user information (1 credit). This part is the only one included in the BREEAM minimum standards.
- Post Occupancy Evaluation (POE) and information dissemination (1 credit)

**Man 05 Life cycle cost and service life planning**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are three.

Through Life Cycle Cost and service life planning, information about the construction, maintenance and operation of the building are provided, in order to make improvements, if needed, and benefit the occupants.
Health and Wellbeing (Hea)

Hea 01 Visual comfort

Only a part of this BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type.

The aim of this issue is to design the building considering that the day lighting, views, internal and external lighting systems and occupant controls can ensure the occupant’s visual comfort.

This issue is split into five parts:
- Pre-requisite (“All fluorescent and compact fluorescent lamps are fitted with high frequency ballasts”) This part is the only one included in the BREEAM minimum standards.
- Day lighting (1-2 credits) - building type dependent (for example, preschools, schools and further education can earn one point, whilst health care buildings up to two, etc.)
- Glare control and view out (1-2 credits) – building type dependent
- Internal and external lighting (1 credit)
- Visual Arts (1 credit) – applies to Healthcare building types only

Hea 02 Indoor air quality (IAQ)

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type.

For this issue, apply an IAQ plan in order to provide appropriate conditions for the health and well-being of the occupants. Consider natural ventilation where possible and removal or control of any sources of contaminants.

This issue is split into three parts:
- Minimising sources of air pollution (3 credits)
- Potential for natural ventilation (1 credit)
Laboratory fumes cupboard and containment areas (2 credits) (only for buildings that contain such facilities.)

**Hea 03 Thermal comfort**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are two.

The aim of this issue is to ensure thermally comfortable living conditions for the building occupants, by achieving the required thermal comfort levels through proper design of the systems (HVAC, Refrigeration, etc.). Include thermal controls for the occupants in order to be able adjust to their individual needs.

**Hea 04 Water quality**

Only a part of this BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one.

For this issue, provide proper design in order to minimize the risk of water contamination (especially against Legionnaire’s disease) and to ensure that fresh clean water is at all times provided to the building users and occupants.

Minimum standard requirement:

“All water systems in the building are designed in compliance with the measures outlined in the Health and Safety Executive’s “Legionnaires' disease - The control of legionella bacteria in water systems”.”

**Hea 05 Acoustic performance**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type and can be:

For Pre-schools, schools and sixth form colleges, three credits

For Further or Higher Education buildings, two credits

For Healthcare Buildings, two credits
For Multi-residential buildings, four credits

For Office, Industrial, Retail, Prisons, Courts and other (nonresidential) building types, two credits.

For this issue, apply proper design, by appointing a qualified acoustician, in order to ensure the building’s acoustic performance.

**Hea 06 Safety and security**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are two.

The aim of this issue is to provide occupants a safe access to the building as well as security when using the building, through proper design.

**Energy (Ene)**

**Ene 01 Reduction of CO2 emissions**

This BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are fifteen.

For this issue, design the building by taking into account the basic parameters of operational energy demand, energy consumption and total CO$_2$ emissions and aim at minimizing them.

**Ene 02 Energy monitoring**

This BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type.

For this issue, promote the installation of energy metering devices that are accessible to the occupants and allow the monitoring of the energy consumption.
**Ene 03 External lighting**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one.

The aim of this issue is to promote the design of external lighting and controls in an efficient manner.

**Ene 04 Low and zero carbon technologies**

This BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are five.

This issue is split into three parts:
- Feasibility study or renewable energy supply contract (1 credit)
- Low or zero carbon technology specification and installation (4 credits plus an exemplary credit)
- Free cooling (1 credit).

By implementing the above to the project, a significant part of the energy is met from RES and other low-carbon technologies, in order to reduce CO₂ emissions and pollution generated from the building.

**Ene 05 Energy efficient cold storage**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are two.

The aim of this issue is to promote the installation of efficient refrigeration systems and their controls, in order to avoid contributing to global warming through Greenhouse Gas emissions.
**Ene 06 Energy efficient transportation systems**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are two.

The aim of this issue is to promote the design and use of energy efficient transportation systems (lifts, escalators, etc.), if any.

**Ene 07 Energy efficient laboratory systems**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type.

This issue addresses buildings with laboratory areas and promotes the design of energy efficient laboratory systems, in order to minimize CO₂ emissions generated from the energy consumption.

**Ene 08 Energy efficient equipment**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are two.

The aim of this issue is to promote the installation of energy efficient equipment and appliances, in order to achieve optimum energy performance through energy savings.

**Ene 09 Drying space**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one.

The aim of this issue is to provide energy efficient equipment for drying clothes, where applicable.
Transport (Tra)

Tra 01 Public transport accessibility

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type.

For this issue, the choice of a site close to public transport networks is encouraged, in order to reduce pollution generated from the use of automobiles.

This credit is split into two parts:

- Accessibility index (up to 5 credits - building type dependent)

The public transport Accessibility Index (AI) for building is calculated and BREEAM credits are awarded as shown in Table 3.7.

Table 3.7: Accessibility Index and BREEAM credits. (source: (BREEAM New Construction, 2011))

<table>
<thead>
<tr>
<th>Accessibility Index</th>
<th>2</th>
<th>4</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Type</td>
<td>BREEAM credits available</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Business: Offices/Industrial, Multi-residential, Other building type 1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pre-school, School, Sixth Form</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Retail, Law Court, Further Education College, Higher Education type 1, Other building type 2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Higher Education type 2</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>Healthcare - Hospitals (Acute, Specialist, Teaching, Mental health)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Healthcare - GP surgery, Health centre, Community hospital</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>Rural location sensitive buildings (see ‘Building type definition’ Compliance note), Other building type 3</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Prison site, MOD site</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Transport hub</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

-Dedicated bus service (1 credit)
**Tra 02 Proximity to amenities**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type.

For this issue, the choice of a site close to local amenities (pharmacy, medical center, sport center, etc.) is encouraged, in order to reduce the use of automobiles from the occupants, thus reducing pollution generated from this use.

**Tra 03 Cyclist facilities**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type.

The aim of this issue is to provide adequate cyclist facilities (cycle spaces, showers, changing facilities, etc.), in order to promote the use of bicycles and reduce pollution due to automobile use.

**Tra 04 Maximum car parking capacity**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type.

For this issue, provide a maximum capacity of parking spaces, in order to encourage the use of alternative means of transport, thus reducing pollution due to automobile use.

The Accessibility Index is calculated and then BREEAM credits are awarded as shown in Table 3.8.
Table 3.8: Building’s Accessibility Index and BREEAM credits (source: (BREEAM New Construction, 2011)

<table>
<thead>
<tr>
<th>Building type</th>
<th>Criteria</th>
<th>No. of credits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Building’s Accessibility Index</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;4</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4 - &lt;8</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Max. parking capacity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 space per x building users, where x is:</td>
<td></td>
</tr>
<tr>
<td>Business – office, industrial, student residences and key worker accommodation</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Sheltered housing, care homes and supported housing for the disabled</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Further &amp; Higher Education</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Other Building – Transport type 1 &amp; 2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Other Building – MOD (where building users are ‘living-out personnel’)</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**Tra 05 Travel plan**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one.

The aim of this issue is to provide occupants with travel options for every possible means of transport, thereby offering choices in order to reduce the use of automobiles for their travels and reduce pollution.
Water (Wat)

Wat 01 Water consumption

This BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are five.

For this issue, the use of non-potable or recycled water for sanitary use is promoted, in order to reduce the overall potable water consumption of the building.

Wat 02 Water monitoring

Only a part of this BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one.

The aim of this issue is to provide water monitoring in order to manage and reduce the water consumption.

Minimum standard:

‘The specification of a water meter on the mains water supply to each building’.

Wat 03 Water leak detection and prevention

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are two.

The aim of this issue is to provide a leak detection system, in order to detect and prevent water leaks.

Wat 04 Water efficient equipment

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one.

This issue concerns irrigation purposes and car wash facilities and promotes the use of water efficient equipment, in order to reduce uncontrolled water consumption.
**Materials (Mat)**

*Mat 01 Life cycle impacts*

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type.

The aim of this issue is to calculate the life cycle impact of the materials used for the construction and promote the use of the ones with a low environmental impact over the whole life of the building.

*Mat 02 Hard landscaping and boundary protection*

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one.

The aim of this issue is to promote the use of low environmental impact materials for hard landscaping and boundary protection.

*Mat 03 Responsible sourcing of materials*

Only a part of this BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are three.

The aim of this issue is to promote the use of responsibly sourced materials for the building elements.

Minimum standard:

‘Confirmation that all timber used on the project is sourced in accordance with the UK Government’s Timber Procurement Policy’.

*Mat 04 Insulation*

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are two.
This issue is split into three parts;
-Pre-requisite: “Any new insulation specified for use for external walls, ground floor, roof and building services must be assessed”
-Embodied impact (1 credit)
-Responsible sourcing (1 credit)
For this issue ensure that the prerequisite applies and promote the use of insulating material that has a low environmental impact and that is responsibly sourced.

**Mat 05 Designing for robustness**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one.
The aim of this issue is to ensure that the design incorporates durability and protection measures or solutions, in order to prevent damages to exposed surfaces or other ‘vulnerable’ elements and reduce the amount of repairs needed.

**Waste (Wst)**

**Wst 01 Construction waste management**

This BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are four.
This issue is split into two parts:
-Construction resource efficiency (3 credits)
-Diversion of resources from landfill (1 credit)
Through the monitoring and management of waste generated during construction, promote their efficient use and divert their disposal on landfills.
Wst 02 Recycled aggregates

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one. The aim of this issue is to promote the use of recycled or secondary aggregates, in order to reduce the use of virgin resources for the construction materials.

Wst 03 Operational waste

This BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one. For this issue, design and provide dedicated areas to serve for storage and recycling of waste generated from the occupants, in order to divert their disposition on landfills or incinerators.

Wst 04 Speculative floor and ceiling finishes

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one. The aim of this issue is to promote the design and use of specific floor and ceiling finishes selected by the owners, where possible, in order to avoid unnecessary waste.

Land Use and Ecology (LE)

LE 01 Site selection

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are two. The aim of this issue is to encourage the selection of a site that was previously developed or contaminated, and decontaminate it, in order to avoid the use of undeveloped “healthy” land. This issue is split into two parts:
Previously developed land (1 credit)
Contaminated land (1 credit)

**LE 02 Ecological value of site and protection of ecological features**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one.

The aim of this issue is to promote the selection of a site situated on “land of low ecological value” and the protection of any features of ecological value during site preparation and construction.

**LE 03 Mitigating ecological impact**

This BREEAM issue is part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are two.

The aim of this issue is to ensure that there is no significant change of the ecological value of the site due to the building development.

**LE 04 Enhancing site ecology**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type.

The aim of this issue is to encourage the enhancing and protection of the ecology of the site, by implementing certain actions reported by a qualified ecologist.

**LE 05 Long term impact on biodiversity**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type.
The aim of this issue is to ensure that biodiversity is protected by trying to minimize the long-term impact the building has on it.

**Pollution (Pol)**

**Pol 01 Impact of refrigerants**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are three.

For this issue provide a refrigerant leak detection system, when needed, in order to avoid leaks and therefore reduce Greenhouse Gas emissions.

**Pol 02 NOx emissions**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are dependent on the building type.

The aim of this issue is to promote the use of heating and cooling systems with low NO\textsubscript{x} emissions, in order to reduce pollution (ozone depletion, acid rain, etc.)

**Pol 03 Surface water run off**

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are five.

This issue is split into three parts;
- Flood risk (2 credits)
- Surface water run off (2 credits)
- Minimizing water course pollution (1 credit)

This issue ensures that the necessary measures to avoid the above are taken, therefore minimizing environmental damages.
Pol 04 Reduction of night time light pollution

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one.

The aim of this issue is to ensure that external lighting systems are appropriately located and operate effectively in terms of consumption, in order to avoid night time light pollution and any neighbor disturbance.

Pol 05 Noise attenuation

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue is one.

The aim of this issue is to avoid affecting nearby noise-sensitive buildings, if any, by taking measures to attenuate the noise levels generated from the development.

Innovation (Inn)

Inn 01 Innovation

This BREEAM issue is not part of the minimum standards required by BREEAM. The total number of credits that can be earned for this issue are ten.

The aim of this issue is to support any new technology, method or process developed by the design team that improves the performance of the building, by rewarding innovation credits (BREEAM New Construction, 2011).
3.2.5 **Comparison between LEED and BREEAM**

LEED and BREEAM are probably the two most widely recognized environmental assessment tools in the building industry today. Even though the development of LEED was influenced by BREEAM, there are significant differences in their philosophies and methodologies.

**Comparison of the environmental categories/sections**

A comparison between the environmental categories of LEED 2009 and the environmental sections of BREEAM 2011, as well as their respective weightings is shown in Table 3.9.

Table 3.9: Comparison between LEED’s environmental categories and BREEAM’s environmental sections (source: M. Sleeuw, 2011)

<table>
<thead>
<tr>
<th>BREEAM 2011</th>
<th>LEED 2009</th>
<th>Weighting</th>
<th>Max. Points</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environmental Section</strong></td>
<td><strong>Max. Weighted % Points</strong></td>
<td><strong>Environmental Category</strong></td>
<td><strong>Max. Points</strong></td>
</tr>
<tr>
<td>Land Use &amp; Ecology</td>
<td>10%</td>
<td>Sustainable Sites</td>
<td>23.6%</td>
</tr>
<tr>
<td>Water</td>
<td>6%</td>
<td>Water Efficiency</td>
<td>9.1%</td>
</tr>
<tr>
<td>Energy</td>
<td>19%</td>
<td>Energy &amp; Atmosphere</td>
<td>31.9%</td>
</tr>
<tr>
<td>Materials</td>
<td>12.5%</td>
<td>Materials &amp; Resources</td>
<td>12.7%</td>
</tr>
<tr>
<td>Health &amp; Wellbeing</td>
<td>15%</td>
<td>Indoor Environmental Quality</td>
<td>13.6%</td>
</tr>
<tr>
<td>Transport</td>
<td>8%</td>
<td>Innovation in Design</td>
<td>5.5%</td>
</tr>
<tr>
<td>Waste</td>
<td>7.5%</td>
<td>Regional Priority</td>
<td>3.6%</td>
</tr>
<tr>
<td>Pollution</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management</td>
<td>12%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Innovation (additional)</td>
<td>10%</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>110%</strong></td>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

The similarities between the categories/sections are very evident. One can say that it is fairly easy to compare the two environmental assessment tools judging from their categories/sections. However this is not the case. The two schemes have different parameters included in their categories/sections that cannot go unnoticed (M. Sleeuw, 2011).
For example, comparing LEED Sustainable Sites only with BREEAM Land Use and Ecology would be a mistake, since many issues included in LEED SS are also covered by BREEAM Transport, Pollution and Management.

The same happens with LEED Energy and Atmosphere, which is mainly compared to BREEAM Energy but also to BREEAM Pollution and Management.

LEED Materials is also mainly compared to BREEAM Materials, however BREEAM Waste and Management cover many similar issues.

**Rating and classification comparison**

Both assessment tools have certain levels of certification that can be achieved, as it was mentioned before, by earning a certain amount of credits. Table 3.10 shows the rating and classification comparison between BREEAM and LEED.

Table 3.10: Rating and classification comparison between BREEAM and LEED (source: M. Sleeuw, 2011)

<table>
<thead>
<tr>
<th>BREEAM 2011</th>
<th>% Points</th>
<th>LEED 2009</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outstanding</td>
<td>≥ 85%</td>
<td>Platinum</td>
<td>≥ 80</td>
</tr>
<tr>
<td>Excellent</td>
<td>≥ 70%</td>
<td>Gold</td>
<td>60-79</td>
</tr>
<tr>
<td>Very Good</td>
<td>≥ 55%</td>
<td>Silver</td>
<td>50-59</td>
</tr>
<tr>
<td>Good</td>
<td>≥ 45%</td>
<td>Classified</td>
<td>40-49</td>
</tr>
<tr>
<td>Pass</td>
<td>≥ 30%</td>
<td>Unclassified</td>
<td>&lt; 40</td>
</tr>
<tr>
<td>Unclassified</td>
<td>&lt; 30%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

However, it should not be assumed that BREEAM’s outstanding and LEED’s platinum correspond to one another. Generally BREEAM is thought to be a tougher environmental assessment tool when it comes to achieving the highest rating. Saunders (2008) studied the BREEAM performance of a UK building that was designed to meet the requirements of LEED. The results showed that if a building is designed to achieve a LEED
Platinum, then it can only achieve a BREEAM Good or Very Good. It should be pointed out that the study was based on earlier versions of BREEAM and LEED.

Another study by Dirlich (2011) came to a similar conclusion. According to Dirlich, LEED assesses buildings more favorably than BREEAM, meaning that it is easier to achieve high rating in LEED.

**Main differences**

The main difference between the two tools is the assessment process. BREEAM has trained assessors who verify the credits, assess the project and file a report to BRE which issues the certificate. LEED does not require a trained professional to carry out the assessment process. However, there is a credit available if an Accredited Professional is used to assess the project and file the report to the USGBC.

Another difference is that LEED uses a consensus-based approach and is fairly more “transparent” than BREEAM. Publicly accessible resources and certification data are available on LEED’s behalf. On the other hand, BREEAM doesn’t publish data on buildings assessed and the ratings that have been achieved.

When it comes to BREEAM’s Minimum Standards, they are different than LEED’s prerequisites. BREEAM sets as a target to achieve higher building sustainability at higher rating levels, while LEED has eight prerequisites that are applied to all ratings. Thus, BREEAM is thought to be pushing harder to improve environmental performance.

On the energy section, BREEAM encourages buildings designed to minimize operational energy demand, consumption and CO₂ emissions, whereas LEED targets energy cost reduction rather than CO₂. Also, BREEAM has a minimum standard of sub-metering substantial energy uses in order to achieve the top ratings and LEED has no such prerequisite. Another difference is that LEED awards Green Power, whereas BREEAM does not award contracts with energy suppliers.

A strong point that LEED has to offer is the fact that there are credits for reducing the Heat Island Effect. BREEAM does award points for green roofs, however for different reasons.

On the Materials section, LEED generally focuses on percentage improvements and BREEAM on the other hand appears to be stricter by setting more absolute targets.
However BREEAM gets more involved. The BRE has produced the Green Guide to Specification, providing useful information about materials in order to achieve credits more easily.

Indoor air quality credits for LEED are much more detailed than BREEAM. The reason is that USA’s climate promotes the design of mechanically ventilated or air conditioned buildings. Therefore there are certain requirements that do not exist in BREEAM.

The travel plan credit that appears on BREEAM’s transport section is more precise when it comes to encouraging alternative transport options to car. LEED only takes account of the accessibility to transport.

On the water section, LEED offers points for the reduction of potable water use for irrigation. BREEAM addresses the subject through the use of efficient equipment but doesn’t quantify a reduction in the use of water.

Finally, a strong point for LEED is that it deals with Post-Occupancy Evaluation (POE). For at least five years all certified projects are reporting energy and water usage data to the USGBC. For BREEAM this issue is included only as an optional exemplary level credit. POE is very important since it provides feedback on the actual environmental performance of the project and can lead to improvements of the assessment method.
4 The Greek building industry

4.1 The existing legislative framework of the building sector

The existing Greek legislative framework that deals with the building sector includes the following. The newly revised General Building Standards (No4067/2012), the Building Regulation, the Building’s Thermal insulation Regulation (Government Gazette 362/4.7.79), the European Directive on the Energy Performance of Buildings (EPBD, Directive 2002/91/EC) and its recast Directive 2010/31/EC. For the implementation of the EPBD there are certain Technical Guidelines that have been approved by the Ministry of the environment.

More specifically, the General Building Standards determine the restrictions and conditions in order to begin constructing any kind of building, reassuring that this way the natural, built and cultural environment are protected.

The Building Regulation reassures that every building meets the following conditions, in order to serve the use that it is built to have.

These conditions are:

- The improvement of the health, wellbeing and security of the occupants
- The improvement of the quality, security, strength and operation of the building
- The protection of the environment
- The saving of energy
- The promotion of scientific research on the construction field
- The increase of productivity on the building sector.

Buildings are divided by this regulation into different types, according to their use. These types are: residential, educational, healthcare, prisons, offices, storage, industrial, commercial and other uses (New General Building Standards (No4067/2012), 2012).

The building’s Thermal Insulation Regulation has been applied since 1979 to every building that has been constructed since then. The goal of this Regulation is to minimize
the thermal losses of a building as much as possible. Greece is divided into four climatic zones and a minimum thermal transmittance coefficient is set for each one of these zones.

The EPBD changes the way buildings are dealt with from the time of its implementation and on. It sets as a goal the search of ways in order to reduce the overall energy consumption of a building that has to do with the heating, cooling, ventilation, lighting and domestic hot water uses. It promotes the use of Renewable Energy Sources, bioclimatic design and the increase of the efficiency of the HVAC systems. More information about this Directive is given on the following section.

4.2 Directive of the Energy Performance of Buildings (EPBD)

The EPBD introduces a holistic approach to the energy design of buildings. It sets as a goal the improvement of the energy performance of the buildings inside the EU, by taking into account the climatic and local conditions, as well as the cost/benefit ratio.

Different measures are required in order to achieve rational use of the energy resources and minimize the environmental impact of the use of energy in a building.

In order to increase energy efficiency in new and existing buildings, the Directive requires:

- minimum predefined goals on the energy performance of new buildings and existing buildings that are subject to major renovation (articles 4, 5 and 6),
- the energy certification of new and existing buildings (article 7),
- Regular inspection of boilers and central air-conditioning systems in buildings (articles 8 and 9).

It should be pointed out that each Member State sets its own standards.

When it comes to the energy certificate, it should be available to the owner or by the owner to the buyer/tenant, every time that a building is constructed, sold or rented. The inspection and certification is carried out by qualified and independent inspectors. The certification should also include advice and information on how to improve the energy performance of the building (Directive 2002/91/EC).
In May 2010 a recast of the EPBD was introduced. The Directive 2010/31/EC sets new goals in order to help achieve the '20-20-20' objectives on energy efficiency, since buildings are a major contributor to energy consumption.

Certain characteristics are taken into account by all Member States when calculating the energy performance of a building. These are the thermal characteristics, the heating insulation and hot water supply, the air-conditioning and lighting installations and the indoor climatic conditions.

The objective of the recast is that by 2020 all new buildings shall be Nearly Zero Energy Buildings. For public buildings this is a binding target and should be set in action by December 2018. (Article 9).

In addition, there are extra financial incentives given on an EU and on a national level. Finally, the Directive introduces the intelligent energy consumption metering systems for newly built or renovated buildings.

The overall aim is to achieve a classification of at least “B” for new constructions and existing renovated buildings (Directive 2010/31/EC).

**Implementation of the EPBD**

The EPBD was transferred into the Greek legislation with the introduction of the Regulation on the Energy Performance of Buildings (Government Gazette 407/9.4.2010). In order to make the study and the inspection of the buildings more specific to the Greek sector, certain Technical Guidelines (T.G.) were introduced. These are:

- T.G.20701–1/2010- Detailed national standards parameters for calculating the energy performance of buildings and issuing the energy performance certificate.
- T.G.20701–2/2010- Thermophysical properties of building materials and checking of the efficiency of the building concerning its thermal insulation
- T.G.20701–3/2010- Climatic conditions of the regions of Greece
- T.G.20701–4/2010- Instructions and forms concerning the energy inspection of buildings, boilers and heating and air-conditioning systems.
The Regulation on the Energy Performance of Buildings

The regulation defines:

- The calculation process of the energy performance of buildings
- The parameters to consider for the calculation process (technical characteristics of the building’s envelope, E/M systems of the building, climatic and internal conditions)
- The Minimum Requirements of the Energy Performance (reference building methodology)
- The contents of the Energy Performance Study
- The authorized individuals that can carry out the Energy Study
- The procedure for the inspection of the buildings, boilers and heating and air-conditioning systems.
- The contents of the Energy Performance Certificate
- The defining of the climatic zones and climatic data.

The inspections included are:

- Building Energy inspection, intended to issue the Energy Performance Certificate and to classify the building
- Boilers inspection, intended to evaluate the state of the boiler systems
- Heating systems inspection, intended to evaluate the state of the heating systems
- Air-conditioning systems inspection, intended to evaluate the state of the air-conditioning systems.
Energy classification of buildings

There are certain categories of energy classification for buildings that are calculated according to the energy consumption levels for every use and climatic zone of a building. The classification is based on the calculated total primary energy consumption in [kwh/m²] and the categories are as shown in Figure 4.1.

![Energy classification categories](source: Gaglia, 2010)

For the Regulation, the reference building methodology is used. According to this methodology there is a reference building that has the same geometry, orientation, operation profile and climatic data as the building that is being assessed. The reference building has always a classification of ‘B’ and all the other categories are now determined according to this building, as a percentage of its consumption. The primary consumption of the assessed building is calculated and then it is classified according to the above. The categories of the classification as are formed according to the reference building methodology are shown in Figure 4.2 (Gaglia, 2010).
Technical Guidelines

The Technical Guidelines were issued in order to support the Regulation of the Energy Performance of Buildings. Their goal is to set the national standards parameters for calculating the energy performance of buildings, as it is defined on the REPB, in order to avoid miscalculations. Those parameters were set according to the technologies used in the Greek building sector (materials, E/M systems), the indoor conditions and the climatic conditions and aim at facilitating the process of the inspection and certification of the building.

The parameters are divided into four categories:

- **Operating conditions of the building**

This includes the identification of the thermal zones, the hours of operation of the building or for each thermal zone, the desirable internal space conditions (temperature, humidity, fresh air, lighting levels), the Domestic Hot Water (DHW) consumption and the internal gains (by users and appliances).
-Building Envelope requirements

This includes the description of the building (dimensions of structural elements, definition of boundaries, building’s orientation, estimation of building’s volume), the thermal characteristics of the building (heat transfer for opaque and transparent building elements, reflection and absorption coefficient, solar heat gain coefficient etc.), the shading factors (horizontal, overhangs and fins), the ventilation (natural, infiltration) and the passive solar systems.

–Requirements for the heating, cooling air-conditioning and DHW systems

For the heating and cooling systems this includes the efficiency of the production, the distribution and the emission system and any auxiliary equipment.

For the DHW this includes the efficiency of the production, distribution and storage system as well as the efficiency of a solar collector if it is included.

For the air-conditioning the efficiency of the production is defined.

–Requirements for the lighting, automatic control, renewable energy sources and cogeneration of Heat and power (CHP)

This includes the performance of the lighting systems, the lighting levels per use of spaces, automatic control systems requirements, RES and CHP requirements.

When it comes to the Thermophysical properties of the building materials, the second Guidance describes the analytical calculation of the thermal transmittance (U) of the building’s elements (opaque and transparent), the surface resistance of the air layer and the mean thermal transmittance of the whole building.

The overall goal is to calculate the building’s primary energy consumption and the total CO2 emission in order to classify the building and to apply Energy Saving Measures if necessary.
5 Relevance of LEED and BREEAM for the Greek Built Environment

Sustainability of constructions has become a matter of great importance for the Greek building sector in the last years. However countries like the U.S.A. and the U.K. have developed rating systems for the evaluation of buildings for many years now. These systems have matured enough to be considered the best for the assessment of buildings not only inside their native countries but even beyond their borders. On the critical side, however, these systems need to evolve even more and become more adaptable and compatible to other countries’ legislation and living conditions. Their relevance for the Greek building conditions is going to be researched by reference to almost each section of these systems.

5.1 Land use

The Regulation for the Energy Performance of Buildings states that in order for a building to be assessed there are certain minimum requirements that need to be met. One of them deals with the design of the building and requires proper siting and orientation, in order to achieve maximum utilization of the local climate, as well as proper landscaping, in order to improve the microclimate. However, it is not stated that construction on undeveloped or contaminated land is considered a ‘plus’, as it is for BREEAM and LEED.

When it comes to the protection of the biodiversity there are laws in Greece that deal with this matter and forbid any action that could endanger protected areas. However this is not included in the Regulation for the environmental performance of the building, but on the other hand it could be said that it is a matter that won’t ever be neglected.

The energy design of a building according to the Regulation does not include matters like the proximity to public transportation like LEED and BREEAM do. The use of alternative transportation in order to reduce pollution from car use is a very important
matter, but it is not included as an energy saving measure when it comes to the efficiency of the building. Similarly, the existence of bicycle parking spaces is not included. However, during the last years there are efforts made throughout Greece in order to develop cycling networks. Many cities have already developed such network, which means that maybe in the future the promotion of bicycle use could be included in the energy efficiency of a building.

5.2 Water

When it comes to the ‘water’ category, BREEAM deals with the reduction of water consumption, water monitoring, water leak detection and efficient water equipment. LEED adds to all the above the issue of minimizing water usage for irrigation.

As far as the Greek conditions are concerned, the issue of water is dealt only in regard of the Domestic Hot Water (DHW) systems, introduced in the Regulation for the Energy Efficiency of Buildings. This includes the efficiency of the production, distribution and storage system of the DHW system, as well as the efficiency of a solar collector if it is included. The daily and annual consumption is calculated per person, by taking into account the use of the building and its floor area (m²).

Automatic control systems for the DHW use are also included in the Regulation as part of the minimum requirements for the newly built buildings.

The efficiency of the DHW system is, therefore, included in the procedure of calculating the Energy classification of a building.

It is highly suggested that issues such as water consumption, rainwater management and reduction of water use are included in the energy assessment of a building. Both BREEAM and LEED find such issues important enough to be included in their certification procedure.
5.3 Building management

The management of the building is an issue set mainly by BREEAM and has to do with the overseeing of the design, construction and finally the handover of the building, in order to make sure that every action is performed as it was supposed to be. It also has to do with the maintenance and operation of a building throughout its lifetime. Such matters are not included in the efficiency Regulation for Greek buildings. Management issues could also include the proper briefing of the occupants in order to make sure that they know how to use energy, water and lighting systems efficiently and thus ensure the proper operation of the building. This is not included on any Regulation either.

However, when issuing an energy performance certificate, the inspector provides the owner with recommendations on how to improve the energy performance of the building and on how to reduce CO$_2$ emissions. This is an effort in helping benefit both the occupants and the environment.

5.4 Energy and atmosphere

The minimization of operational energy demand, consumption and CO$_2$ emissions is the main goal of the Greek legislation that deals with the sustainability of the built environment. The issuance of the energy certificate classifies the building after calculating its primary and final energy consumption and the total CO$_2$ emissions.

The minimum energy performance and the measures that can be implemented in order to achieve the minimum level (B) will be mandatory by 2020. This is a great step towards the sustainability of the building sector.

Another issue that is already included in the Regulation is certain requirements for the lighting, automatic control, renewable energy sources (RES) and Cogeneration of Heat and Power (CHP). Through this process, the use of solar collectors, photovoltaic systems and RES in general is encouraged, in order to achieve higher levels of performance. Similar issues are included in BREEAM and LEED and are considered to be of significant importance.
The use of insulation is also a very important matter for the Greek building industry and especially the proper installation of the insulating material during construction.

The refrigerant management, in order to reduce ozone depletion as well as the use of appliances with high efficiency, are issues not included in the classification process. However, the energy classification of appliances was established in the EU with the Directive (92/75/22.09.92) and on a national level with the release of the Presidential Decree 180/1994. According to this, the energy classification of the appliances used (refrigerators, ovens, washing machines, dryers, etc.) should be confirmed with an ‘energy label’ on the exterior of the appliance. Thus, the consumers are informed on the energy efficiency of the appliance they purchase and/or use. Therefore, these are matters known to be of great importance and could be included in the future in the certification process for the energy performance of the building.

5.5 Materials

For the time being there is no assessment tool for the materials used for the construction, including the insulation. Therefore there is no result for their impact on the environment and they cannot be associated to the materials used in other countries. Materials are classified in terms of the energy they consume and this classification defers from country to country, depending on their availability and their energy consumption during the production process, their transportation, etc. However, in Greece, there are studies that are dealing with this matter. For example, Giamma and Papadopoulos (2009) developed a tool that classifies the most commonly used construction materials according to their environmental impacts, energy consumption and costs. BREEAM uses a similar approach with the Green Guide to Specification that is used for information on the most commonly used construction material and their impacts on the environment. Therefore, it is evident that this is an issue that could possibly be included in the future in the certification process.

The issue concerning the waste management is covered by the Greek legislation by the: “Measures, terms and programming for alternative management of waste from excavation, construction and demolition” (Government Gazette 534B/ 20.6.95). This aims at
the prevention and reduction of the environmental impacts caused by the generated waste and at taking the necessary measures to succeed it.

Reuse, recovery and especially recycling of construction materials are all issues that are dealt with in the legislation. There is even a Certificate of Alternative Waste Management issued that certifies and encourages the proper waste management.

What is not included is the proper waste management on behalf of the occupants, in terms of recycling their own waste, after the commissioning of the building. BREEAM and LEED seem to focus on such matters and the Greek building sector shows an interest in them too. Therefore it seems logical to assume that such issues could be included in the Building certification process in the future.

5.6 Indoor Air Quality (IAQ)

As mentioned before, the Technical Guidelines set certain parameters for calculating the energy performance of buildings. One of them is the one that defines the operating conditions of the building. This parameter includes the desirable internal space conditions.

The internal space temperature levels are defined per use of the building and of course these levels are different per season of the year. Table 5.1 shows these temperature set points.

On the same note, the relative humidity is defined per use of the building and per season.

The required fresh air (natural ventilation) is defined by the use of the building, the number of occupants and the levels of pollutants that are produced mainly due to the use of the building. It is determined by National Standards and for Greece it is as shown in Table 5.2 below.
Table 5.1: Temperature set points in °C (source: Technical Guideline 20701-1/2010)

<table>
<thead>
<tr>
<th>Building type</th>
<th>Temperature °C</th>
<th>Relative Humidity [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heating period</td>
<td>Cooling period</td>
</tr>
<tr>
<td>Residential</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Bank</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Bar/Restaurant</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Concert hall</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Conference hall</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Gym</td>
<td>18</td>
<td>25</td>
</tr>
<tr>
<td>Hospital, medical unit</td>
<td>22</td>
<td>26</td>
</tr>
<tr>
<td>Patient room</td>
<td>22</td>
<td>25</td>
</tr>
<tr>
<td>Operating room</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Outpatient clinic</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Hotel (continuous operation)</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Hotel (seasonal operation)</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Kindergarten</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Library</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Museums</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Office</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Pharmacy</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>Shopping center</td>
<td>19</td>
<td>25</td>
</tr>
<tr>
<td>Theater, Cinema</td>
<td>20</td>
<td>26</td>
</tr>
<tr>
<td>University</td>
<td>20</td>
<td>26</td>
</tr>
</tbody>
</table>

Table 5.2: Natural Ventilation per use of the building (source: Technical Guideline 20701-1/2010)

<table>
<thead>
<tr>
<th>Building type</th>
<th>Occupants/100 m² floor area</th>
<th>Air flow [m³/h/person]</th>
<th>Air flow [m³/h/m²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>5</td>
<td>15</td>
<td>0.75</td>
</tr>
<tr>
<td>Bank</td>
<td>40</td>
<td>30</td>
<td>12</td>
</tr>
<tr>
<td>Bar/Restaurant</td>
<td>80</td>
<td>70</td>
<td>56</td>
</tr>
<tr>
<td>Concert hall</td>
<td>100</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>Conference hall</td>
<td>75</td>
<td>30</td>
<td>22.5</td>
</tr>
<tr>
<td>Gym</td>
<td>75</td>
<td>45</td>
<td>33.75</td>
</tr>
<tr>
<td>Hospital, medical unit</td>
<td>30</td>
<td>70</td>
<td>21</td>
</tr>
<tr>
<td>Operating room</td>
<td>22</td>
<td>35</td>
<td>7.7</td>
</tr>
<tr>
<td>Outpatient clinic</td>
<td>20</td>
<td>80</td>
<td>0.25</td>
</tr>
<tr>
<td>Patient room</td>
<td>10</td>
<td>45</td>
<td>4.5</td>
</tr>
<tr>
<td>Hotel (continuous operation)</td>
<td>15</td>
<td>30</td>
<td>4.5</td>
</tr>
<tr>
<td>Kindergarten</td>
<td>50</td>
<td>22</td>
<td>11</td>
</tr>
<tr>
<td>Library</td>
<td>22</td>
<td>19</td>
<td>4.18</td>
</tr>
<tr>
<td>Museum</td>
<td>80</td>
<td>22</td>
<td>17.6</td>
</tr>
<tr>
<td>Office</td>
<td>10</td>
<td>30</td>
<td>3</td>
</tr>
<tr>
<td>Shopping center</td>
<td>14</td>
<td>22</td>
<td>3.08</td>
</tr>
</tbody>
</table>
The goal of applying all the above is to achieve thermal comfort without wasting energy.

Finally, the suggested lighting levels are given, as well as any information having to do with the designing of the lighting systems, in order to achieve the desirable visual comfort.

Acoustic performance is an issue that is not included in the performance of the building even though acoustic insulation is an important matter for the Greek building industry (included in BREEAM).

Another point that is not included is the reduction of the indoor air contaminants that are harmful for the occupants (included in LEED).

Nonetheless, the issue is covered rather extensively, even though there is still room for improvements.

5.7 Examples of Implementing BREEAM and LEED to Greek buildings

The following examples show that it is very possible to implement certain measures in order to be able to achieve points/credits according to the LEED and BREEAM certification process for Greek projects.

5.7.1 Implementation in Greek Office Building

Papadopoulos and Giamma (2007), implemented BREEAM and LEED in a Greek office building situated in the city of Thessaloniki. Their goal was to implement simple measures of sustainability according to BREEAM and LEED, in order to achieve certification.

Firstly, a number of data (architectural drawings, floor and ceiling construction details, materials used, HVAC system’s characteristics, energy and water consumption data, etc.) was gathered in order to evaluate the building.
Through this process, it became evident that high levels of energy consumption were due to office equipment and air-conditioning. At the same time, the issue of the proper thermal insulation should be considered, as well as the one concerning the waste management of the building. Table 5.3 shows the results of the BREEAM evaluation at the design phase.

Table 5.3: BREEAM evaluation results at the design phase for office building in Greece (source: Papadopoulos, Giamma, 2007)

<table>
<thead>
<tr>
<th>Environmental Aspects</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Building Management</td>
<td>5.1 credits</td>
</tr>
<tr>
<td>2  Health and Wellbeing</td>
<td>6.924 credits</td>
</tr>
<tr>
<td>3  Energy</td>
<td>0.76 credits</td>
</tr>
<tr>
<td>4  Transport</td>
<td>1.52 credits</td>
</tr>
<tr>
<td>5  Water</td>
<td>3.32 credits</td>
</tr>
<tr>
<td>6  Materials</td>
<td>4.16 credits</td>
</tr>
<tr>
<td>7  Land use</td>
<td>9 credits</td>
</tr>
<tr>
<td>8  Pollution</td>
<td>2 credits</td>
</tr>
</tbody>
</table>

Almost 32 credits were awarded to the building, which at the time meant it was not certified (36 credits needed).

Some of the measures that were implemented in order to achieve BREEAM credits were:

Building management:
- monitoring of the building management commissioning
- reports on the building management
- monitoring of water consumption during construction
- construction waste management monitoring

Health and wellbeing
- adequate day lighting
- occupant controlled glare control system installed
- evidence on waterborne and airborne contamination minimization
- control of internal noise

Energy:
- lighting controlled by systems which operate by daylight presence

Transport:
- Good access available to and from public transport networks

Water:
- Location of the building in a zone with low annual probability of flooding
- Water metering
- Leak detection system installed

Materials:
- Selection of materials according to their origin (sourcing of materials)
- Third party certification for timber
- Accessible storage space for the recycling of materials

Land use:
- Selection of previously developed site
- Land of the site characterised as contaminated
- Decontamination of the site
- Land of low ecological value (evidence)

Table 5.4 shows the results of the LEED evaluation at the design phase.

Table 5.4: LEED evaluation results at the design phase for office building in Greece (source: Papadopoulos, Giamma, 2007)

<table>
<thead>
<tr>
<th>Environmental Aspect</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Sustainable Sites</td>
<td>Max credits 8</td>
</tr>
<tr>
<td>2 Water efficiency</td>
<td>Max credits 4</td>
</tr>
<tr>
<td>3 Energy and atmosphere</td>
<td>Max credits 4</td>
</tr>
<tr>
<td>4 Material and resources</td>
<td>Max credits 4</td>
</tr>
<tr>
<td>5 Indoor Environmental Quality</td>
<td>Max credits 8</td>
</tr>
<tr>
<td>6 Innovation in design</td>
<td>Max credits 2</td>
</tr>
</tbody>
</table>

The office building earned 30 points according to LEED and managed to be certified. Some of the measures that were implemented in order to achieve LEED points were:

Sustainable sites:
- sustainable site selection
- access to public transportation networks
- parking capacity
- protection of the ecological value of the land
- storm-water design
- minimization of lighting pollution

Water efficiency:
- wastewater management
- water efficient landscaping
- 20% reduction of water use

Energy:
- reports on the energy consumption
- improvement of the energy performance

Materials:
- 50% management of the construction materials
- 5% reuse of materials
- 10% recycled content materials

IAQ:
- increased ventilation
- implementation of an IAQ management plan
- use of low emitting materials
- lighting control system implemented
5.7.2 Greek retail building certified with BREEAM

The Greenstore Stamata Supermarket achieved a ‘very good’ rating at the post-construction stage according to the BREEAM evaluation process.

It is the first Greek commercial building to achieve BREEAM certification.

The features that were implemented and lead to the certification are:
- A building management system (BMS) with real time metering and control
- Photovoltaic (PV) panels
- Geothermal heat pump
- Wind turbine
- Rainwater harvesting
- Heat recovery in cold storage systems
- Sun pipes to enhance natural daylighting
- Water metering and a leak detection / prevention system
- Electric vehicle charging stations (energy provided by the building’s renewable energy systems)
- A compactor for packaging waste and the composting of organic waste (building for change, the BRE trust, 2012).
6 Conclusions

Building construction and operation requires spending great amounts of energy, water and materials and at the same time generates significant amounts of waste. Therefore, it has become a necessity to intervene in the building sector and more specifically to take into account the environmental impacts when making any decisions.

To this direction Green building assessment tools were developed as an attempt to focus on sustainability as well as economic and social benefits when it comes to the construction sector.

This thesis deals with the two most well-known Green building assessment tools, LEED and BREEAM, by presenting their history, features, the assessment processes which they follow and the environmental categories/sections each one of them focuses on. After this presentation a comparison between these two tools is made, in order to highlight their similarities and their differences when dealing with the environmental assessment of buildings.

Greece deals with the issue of sustainability in the building sector with the introduction of EU’s Directive for the Energy Performance of Buildings which is transferred into the Greek legislation with the introduction of the Regulation on the Energy Performance of Buildings.

This thesis presents the current legislation regarding the Greek building sector and especially the process followed for the energy specification and classification of newly built and existing buildings.

After presenting the above, the relevance of LEED and BREEAM for the Greek Built environment is researched through the examination of whether the issues that are included in the Green Building tools are considered in the Greek environmental assessment process and to what extent, and if not, whether they could be included in the future.
6.1 Conclusions regarding LEED and BREEAM

The development of LEED was influenced by BREEAM and this is something that is evident by just looking at the environmental categories of LEED, and BREEAM’s environmental sections. However, they appear to have many differences from one another.

First of all, their categories/sections are not equivalent. BREEAM has more sections than LEED’s categories and therefore, many issues included in a LEED category correspond to more than one BREEAM section.

Their rating and classification results also do not correspond to one another. Generally BREEAM is thought to be a stricter environmental assessment tool when it comes to achieving the highest rating. Many studies have shown that it is fairly easier to achieve a high rating in LEED than it is in BREEAM.

BREEAM requires trained assessors to carry out the certification process, whilst LEED offers additional credits for the use of an accredited professional to assess the project, but doesn’t consider it to be an obligatory issue.

LEED appears to be more ‘transparent’ than BREEAM, concerning its accessibility to resources and data.

BREEAM’s Minimum Standards and LEED’s prerequisites are not equivalent. BREEAM pushes harder to achieve sustainability, since the higher the rating levels are, the higher is the sustainability. For LEED the prerequisites are the same for every level of certification.

For the energy section, LEED targets energy cost reduction rather than CO₂ reduction, whereas BREEAM encourages the minimization of operational energy demand, consumption and CO₂ emissions and encourages sub metering of the energy uses.
One of LEED’s strong points is the awarding of credits for the reduction of the Heat Island Effect, which is not included in BREEAM.

On the Materials section, LEED focuses on incremental improvements, whereas BREEAM appears to be stricter, by setting absolute targets. It gets more involved with this issue with the use of the Green Guide to Specification, which contains information about materials and their environmental impacts.

LEED gets more involved when it comes to the Indoor Air Quality section with details that do not exist in BREEAM.

BREEAM’s transport section is more precise since it encourages the use of alternative transport, by proposing a travel plan. LEED only assesses the accessibility factor.

BREEAM addresses the issue of water by promoting the use of efficient equipment and doesn’t quantify a reduction in the use of water, whereas LEED awards credits for the reduction of the use of potable water for irrigation purposes.

A very strong point for LEED is the fact that it deals with Post-Occupancy Evaluation (POE), with reports on energy and water usage data submitted to the USGBC, whereas BREEAM deals with this issue as an optional exemplary level credit.

6.2 Conclusions regarding the relevance of LEED and BREEAM for the Greek reality

The energy classification and certification process for Greek buildings appears to have some relevance with certain LEED and BREEAM categories/sections. However there are certain issues addressed by these systems that are not included in the Greek certification procedure and that are important enough for the Greek authorities to consider including them in the future.
Construction on undeveloped or contaminated land is an important issue for BREEAM and LEED and is not included in the certification process of Greek buildings. However, there is legislation regarding the protection of land of ecological value.

Proximity to public transportation and the promotion of bicycle use through the design of racks and changing areas are also issues not included. However, due to the severity of pollution due to car use, and since there is evident development of cycling networks in Greece, this is an issue that could and should be included.

Issues such as water consumption, rainwater management and reduction of water use are important issues that are included in both LEED and BREEAM and are not considered in the Greek certification process, except for the DHW use and its metering.

Other than the recommendations of the inspector on the improvement of the building’s efficiency when issuing the energy efficiency certificate, the management of the building is not included in the certification process. BREEAM is the one mainly setting this issue.

The minimization of operational energy demand, consumption and CO₂ emissions are the main goal of the Greek certification process and are issues thoroughly examined. What is not included and is important for both LEED and BREEAM is the refrigerant management and the use of efficient appliances in order to reduce energy consumption. The fact that the energy classification of appliances is obligatory for Greece is a step to that direction that can help include this issue to the process.

An assessment tool for the materials used for the construction, including the insulation does not exist for the Greek building sector, thus there is no official information regarding their environmental impact and this important issue is not include in the certification process.

The Greek legislation covers the issue of waste management from excavation, construction and demolition, however it is also not included in the certification process and neither is the waste management on behalf of the occupants.
Indoor Air Quality is an important issue for the building certification process in Greece, although there is room for improvement by including the minimization of indoor air contaminants and acoustic performance of the building, issues that are important for the health and wellbeing of the occupants and are included in both LEED and BREEAM.

To sum up, the Greek Standards need to consider adopting the more inclusive and comprehensive approach demonstrated in BREEAM and LEED. Towards achieving this goal the following may be of assistance:

- carrying out a thorough national research of the LCA of locally available materials, both locally produced and imported ones
- promoting the issues of water consumption, rainwater management and the reduction of water use
- establishing benchmarks for indoor air contaminants and acoustic performance levels
- encouraging refrigerant management
- encouraging the use of alternative transport by promoting the use of bicycles and public transportation
- promoting the reuse and recycling of waste generated from the occupants, by establishing a waste management plan for buildings.
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