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ARE GREEN BUILDING CRITERIA ACHIEVING THEIR GOALS? A CRITICAL COMPARATIVE ANALYSIS OF LEED AND CASBEE

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A thesis submitted for the degree of

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ABSTRACT

This thesis was written as a part of the MSc in Energy Systems at the International Hellenic University. The purpose was to compare two of the several rating systems that exist in many countries for the certification of Green Buildings.

The Leadership in Energy and Environmental Design (LEED) developed in the United States and the Comprehensive Assessment System for Built Environmental Efficiency (CASBEE) developed in Japan were critically analyzed and their weaknesses identified. At the same time, it was found that some strengths belonging to either one could be incorporated into the other to improve its flaws.

This paper would not be possible without the guidance of Professor Isaac A. Meir, who did his best to advise and support me with honest and meaningful feedback.

Paola Liliana Alonso Trejo

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INTRODUCTION

Growing energy demand is a great challenge to be met and along with production comes depletion of resources and industrial processes that contribute to the release of pollutants and Greenhouse Gas (GHG) emissions. This commodity requirement is linked with thermal comfort and sustainable living and creates a vicious cycle where needs cannot be met as our energy consumption creates a situation that escalates the conditions that call for further energy production. Therefore, green buildings help breaking such cycle. However they involve critical design and suitable use of resources in order to be functional and here is where the green building criteria come into place to evaluate and define if a building is really serving its purpose of improving the environmental conditions.

The Green Building Councils in different countries have approached the issue with their own tools all with a common goal in mind: to rate how "green" buildings are. These evaluation systems are a voluntary commitment to meet energy efficiency goals, to improve microclimates, to encourage the use of recycled materials and to provide high indoor air quality, etcetera.

Policies, which - in contrast with the voluntary rating systems - are legally enforced, have been developed to ensure a commitment with the Kyoto Protocol purposes of greenhouse emission reduction, which incorporate the aforementioned objectives of green building.

However, simply having the same purpose is at times insufficient. The assessment tools still have a long way to go to being completely effective, as geographic and socioeconomic differences exist between different areas of the world. For this reason, the systems must continually be improved in order to reach energy efficiency.

It is through this critical lens that this study is conducted.

CHAPTER 1. HOW EVERYTHING STARTED

1.1 A TURN OF EVENTS

It goes back many decades; consciousness of the world's environmental problems is not a new trend; climate has been changing dramatically in the last thirty years. Reasons are numerous, among them the changing relations between living organisms and their surroundings – the effects of those interactions that mainly have to do with satisfying the population's needs, which have been exacerbated. This is why in the 1960's, Environmentalism emerged as a movement inspired by the desire of preserving natural resources through better management and use of them. The belief in the need of maintaining natural areas unaltered by human activities has also motivated the search of new ways to develop certain living standards without compromising what the planet Earth needs in order to sustain life as we know it.

A milestone publication that changed the perceptions of people about human intervention in nature and subsequent damages was *Silent Spring* (Carson, 1962). The author, Rachel Carson, put on the spot the dominance of industrialization and its damaging actions in order to meet the population's needs without considering what is to be harmed, actions that contaminated land, water and air, and which effects could not be reversed easily. She wrote about chemicals contained in substances or materials that were supposed to support human needs. Such compounds unfortunately are so widespread that living organisms cannot avoid coming in contact with them either directly or indirectly. Mainly the focus of the book was centered on how the power of man has altered nature.

All these industrialized activities were never meant to be destructive or to harm the environment. They were not what anyone would have wished, and their impact had not been anticipated. Urbanization and human advancement took so much attention that preservation of wildlife and its habitats were overlooked and additional consequences were observed recently when climate change was more systematically documented and better understood (Carson, 1962).

Alongside those processes, the world faced a great challenge in the seventies: the oil crisis. It brought attention to issues related with energy supply and depletion of resources. The importance of fossil fuels was felt with the rise of oil prices, and although it only lasted roughly five months, it made governments realize their importance and how dependent society is on them. Prices rose and people's dependency on oil became apparent. Alternatives were considered, renewable energies took off, and wind and solar power as well as biofuels entered the market. Consumer behavior started to take another direction in some parts of the globe, and the demand for green products went up as environmental interest grew (Peattie, 1992).

Therefore, as more studies were carried out on the interactions of human activities with the environment, it was better understood how industrial processes become great contributors to the release of pollutants and greenhouse gas emissions. Among the latter, carbon dioxide is prominent, but what is now attracting attention is the extent to which the building sector has had a great impact on the environment. The difficulties lay in the pace at which population continues to grow, with the damages that this entails, and consumption per capita of modern society (IEA, 2012).

1.2 THE BUILDING INDUSTRY: HOW DOES IT RELATE TO THE ENVIRONMENT?

In order to have a clear idea of the effects that buildings have on the natural systems, it is fundamental to acknowledge their interdependence. Buildings require energy, materials and water and construction processes so as to serve their purpose.

According to Ramachandran (1990), there are four categories of environmental impact occasioned by buildings:

- Resources depletion. In this classification the concern has been the exploitation of non-renewable resources such as minerals and fossil fuels.

- Physical disruption. Construction process, maintenance, renovations and demolition have a complex relationship with the environment, usually with negative effects.
- Pollution. Materials are the greatest contributors in this respect. Toxic materials lead to many health problems, and the sick building syndrome is one of the outcomes.
- Social and cultural effects. As urban areas develop, the social environment undergoes adjustments that have impacts on society. Cultural sensitivity has not been taken into account, nor have visual impacts.

Consequently, concerns about the built environment spread worldwide, and as mentioned previously, eyes have been on the building industry. What makes those concerns particular is that the life cycle of a building engages a flow of materials and resources that is endless and continuously moving (Ramachandran, 1990).

According to the Intergovernmental Panel on Climate Change (IPCC) and its Report on Renewable Energy Sources and Climate Change Mitigation (IPCC, 2012), the greenhouse emissions associated with the provision of energy systems are major causes of climate change. The building sector is one of the main contributors. On the other hand, the Environmental Protection Agency (EPA) reports that global emissions divided by economic activities such as energy supply and the commercial and residential buildings respectively produce 26 percent and 8 percent (EPA, 2012). These activities involve burning coal, natural gas and oil.

In a different report, the International Energy Agency announces that buildings around the world account for more that 40 percent of primary energy consumption, this being the main source of greenhouse gas emissions (EPA, 2012). That refers to the direct use of energy when this has not undertaken any transformation, meaning natural gas and oil extraction, and the prediction has been made that the greenhouse emissions will double in the next twenty years. But not only energy consumption contributes; besides it, the high consumption of water and materials, and waste generated in the buildings, represent almost 50 percent of the total solid waste generated every year. Observing other figures, in the

United States it has been calculated that 65 percent of the total electricity consumption is by buildings, and that they generate over one third of the total greenhouse emissions all over the world (EPA, 2012). When looking at the picture regarding the use of energy in the building sector, primarily residential and commercial building, in the Buildings Energy Data Book published by the United States Department of Energy (DOE) in 2010, the energy use was around 18.7 percent of the world's total. Meanwhile, in the same sector, the European Union represents 15.7 percent, Japan with 4 percent and Mexico 1.6 percent. These numbers include single- and multi-family residences and commercial buildings that encompass stores, offices, restaurants and other buildings used for commercial purposes, as well as government facilities. Consequently, mitigation of pollutant releases must be the biggest driver to adopt strategies to overcome the pollutants because all these consumption values are interconnected with the former in their production process. Therefore, given the high demand for energy mentioned above, a transformation of conventional buildings is necessary, as they have the potential to adapt in them elements that help reduce the high statistics of those elements affecting the environment. What characterize the energy consumed in the building sector are the following activities involved in the whole process (UNEP, 2009):

- Production of building materials
- Transportation of materials
- Manufacture/construction/production of buildings
- Operation phase of the building. This category stands above others because most of the energy is used here during the lifespan of the building's use and its continuous aim of meeting basic needs such as water heating, air conditioning, lighting, ventilation and heating.
- Demolition

Additionally, buildings have a long lifespan, which provides the opportunity to take actions for renovations and improvements, and still make a change in the impact to the environment. It is here where green buildings come into play. They are bound to sustainability, hence to better use and allocation of resources, making their interaction with the environment less harmful.

1.3 LIFE CYCLE ASSESSMENT (LCA)

Since buildings have a long lifespan, considerations about their impacts on the environment have to be taken into account throughout their life cycle. The process might be difficult because of the complex building-environment interactions; that is how the Life Cycle Assessment helps in gaining a better understanding (Graham, 2003).

This methodology is part of the ISO 14000 environmental standards, and is focused on materials, their lifespan and their environmental implications. However, it is important to include it in this part of the document because it is closely related to what the building rating systems attempt to carry on through their own assessments, and also with the concept of sustainability in the building sector (ISO, 1998).

The well-known approach of LCA is the "cradle to grave" consideration, accounting from the gathering of raw materials used in the making or creation of a product, going under all the necessary transformations, being utilized and then disposed of at the end of its life. The information delivered by this examination allows the understanding of the environmental impacts that result from manufacturing processes and from the energy use embodied in them (SAIC, 2006).

The EPA in 2006 officially defined the LCA as a series of steps that begins with the inputs involved, such as raw materials and energy, followed by four defined stages:

1. Extraction of raw materials
2. Fabrication processes
3. Use, reuse and maintenance
4. Management of recyclables and wastes

When the previous steps are completed, the LCA finalizes with the report of the different yields like atmospheric emissions, solid waste, water carrying waste, etcetera, as the products of the manufacturing of a building.

As may be seen, the assessment aims strictly at evaluating the aspects of products and their processes related to the environment. Among the information that can be obtained are the following:

a) Stock of the inputs used and how they are related to energy consumption
b) Potential environmental impact
c) Results that aid decision makers when purchasing or considering the use of certain material, giving them the complete information they require

Hence the LCA can be applied not only to materials; studies have shown that its application in the building industry is reliable, although it may take the adoption of holistic perceptions that include services such as indoor air quality, heating, sanitary facilities, cooling, etc. (Guardili et al, 2011). This means that evaluation covers extraction of materials, manufacturing, use of materials in the construction, maintenance and demolition, and also includes planning costs, transport in and out of the site, HVAC systems, waste disposal and recycling. Finally all this entire-building approach incorporates the building material cycles into it.

Although such assessment is not easily determined, it is possible to achieve effective results from it. The process is trustworthy so as to generate information that potentially could make a building fit into the adequate parameters of human health, ecosystems quality and resources, without forgetting that life cycles of buildings vary and their performance undergoes variations.

1.4 BUT, WHERE DOES HUMAN HEALTH FIT?

Mentioned previously as part of the LCA, human health is related to the development of buildings. Approximately thirty years ago, the World Health Organization started to give importance to the quality of air indoors because of the relation between health problems and chemical, physical and biologic agents, and because the time that occupants spend indoors in many of the industrialized countries is almost 90 percent of their entire life activities (EPA, 1991).

In urban scale, the sprawl of cities has exposed populations to environmental hazards; one of the most threatening is the so-called ''Sick building syndrome" (SBS), which is intrinsically related to mental and physical health (Von Schirnding, 2002).

In spite of being a phenomenon that many times lacks credibility, it is defined as an intense short-duration symptom or group of symptoms that occupants present in their health that appear to be related with the time they spend in a building and which tend to disappear as soon as the building is left.

According to the EPA (1991), many factors can cause this syndrome, such as inadequate ventilation, chemical contaminants from indoor and outdoor sources, as well as biological contaminants. Hence, the importance of the SBS must be remarked when talking about the transformation of the building sector and toward the concept of green buildings.

1.5 URBAN HEAT ISLAND

Due to the densely built environment developed by the building sector and existent in the urban areas, this phenomenon is a constant challenge and it relates to environmental issues, mostly to the increase of temperatures in such regions and changes in landscapes. Santamouris (2012) explains it as the comparison of higher urban temperatures with those in the neighboring suburban or rural areas, often discovered to be lower.

The Urban Heat Island (UHI) derives mostly from human activities; it is another outcome of the expansion of cities and industrialization. It is mainly caused by the heat released by vehicles, power plants, manufacturing of goods, air conditioning units, etcetera.

Additionally as urban areas expand, the inclination toward less green spaces deteriorates the living environment and increases energy consumption (Rizwan et al, 2007). Furthermore, building materials have a property of absorbing heat and retaining it when the sun sets, not allowing cities to cool down at night.

Two mitigation measures may be mentioned (Santamouris, 2012):

- Raising the albedo of roofs (reflective roofs) to avoid the building materials absorbing great amounts of heat and storing them. Instead, coatings that help reflect solar radiation can make a difference in the air temperature by shrinking the effect to a rise of only 10°C (Berdahl and Bretz, 1997) instead of 50°C when having high absorptive roofs.
- Green roofs. Planting trees and having more vegetation reduces atmospheric CO_2 through carbon sequestration in the photosynthesis process (Akbari, 2001)

Accordingly, the rating systems have included these mitigation methods, and that is one more factor that helps define the relationship between building and environment.

1.6 JOINING THE GREEN BUILDING MOVEMENT AND ITS CONNECTION WITH SUSTAINABILITY

This concept was first brought to attention in the 1930's when the Green Movement (Carson, 1962) started to take actions in order to protect the environment, but defining green buildings is not an easy task. Many times it is outlined by certain parameters; but for many professionals, locations and governments the concept can be diversified. Overall the building should be equipped with efficient water and energy systems, incorporate green building materials and reduce impacts on human health and the environment. Green building materials are characterized as being beneficial to the ecosystems and negative environmental impacts are not a result of their use; they also can be recycled, reused and made from renewable sources (Kubba, 2010).

The Environmental Protection Agency (EPA, 2010) for example, defines the movement as:

"The practice of creating structures and using processes that are environmentally responsible and resource efficient throughout a building's cycle from siting to design, construction and operation, maintenance, renovation and deconstruction"

Green building design philosophy is centered on environmental sensitivity, and this can only be achieved through a holistic development of knowledge and practices that lead to the success of low energy consumption, since one of the model's goals is the reduction of the reliance on energy. The green building movement involves processes that are environmentally responsible, and siting, construction, design, operation, maintenance and renovations must prioritize the preservation of the environment and human health. But not only those goals are contemplated; the scope expands to the energy and maintenance cost reduction, the use of renewable resources is encouraged, and the depletion of those that have been overused and that cannot regenerate as easily is to be avoided. A building that is envisioned to perform as part of the green movement should be made to last many years: quality is an important component since what is desired is to reduce operational costs and to promote the health, wellbeing and productivity of the occupants.

A sustainable building then is defined as one that uses energy, water, materials and land in efficient ways and complies with the eco-friendly concept of not harming the environment (Kubba, 2010), while also taking into consideration user comfort and Indoor Air Quality (IAQ). Furthermore, sustainable development brings changes in the design of these buildings and focuses on the smart use of resources available, on the long-term consequences that the construction might bring and always takes into consideration the provision for whatever needs have to be met in the future.

Moreover, these buildings are changing conventional design; they are giving more creative options to architects, engineers and designers and offer a whole new perspective of modern design.

The significant benefits of green buildings are:

- Energy and other resource savings
- Protection of the environment
- Human health improvement

These benefits are also considered as the goals to be achieved, but as population grows they become harder to meet, as the larger the population, the higher the demand. Going green is all about making the right choices to benefit the environment, and it is not necessarily more expensive than conventional methods. It is also about blending design with nature; in order to do so, the climate of the location must be known (which means that design is site-specific) and well studied. At the same time, this knowledge helps with understanding the resources that are available and the limitations for the building.

However, being aware of sustainability or green buildings is not enough. Regulations, measurements of emissions, identification of health hazards and standardization exist but must be fully implemented so as to evaluate certain criteria and grant the title of “green”. Policies must be designed in a way that encourages owners to renovate their buildings and motivations such as installation of new and modern technologies that help reduce energy consumption should be enhanced.

At the same time, voluntary assessment tools have been developed all over the world. Despite certain problems with their assessment methods, they may be the tools that will change buildings, and thus their relations with the environment, aiming for a sustainable future.

1.7 DRAWBACKS AND MISCONCEPTIONS

A drawback of the movement is the misconception that occupants have about the green structures being more expensive and complicated to operate. Although it is true that they have certain characteristics that are superior to those used in conventional and traditional structures, reality is that at the end of the project the differences are unnoticeable (Kubba, 2010).

But opposition to green is not the main problem; apparently for some authors the terminology of “green” has been misused and directed to marketing purposes (Murphy, 2009). While it is true that rating systems or life cycle assessments might not be accurate and may be highly expensive in some cases, it does not necessarily mean that they are a complete failure.

In a study ran by Chau and Tse (2010) about the perception that consumers have on green buildings, they find out that people are willing to pay more to enhance green performance of their buildings. An interesting finding was, that regardless of their willingness they were only focusing on the energy efficiency measures, whereas they have left out other pieces such as indoor air quality, or even water conservation. Apparently, this tendency was present because of the lack of information about the components of green performance; it was concluded that as long as there is an effort to keep the public informed and educated in the matter, they will be more inclined to adopt other measures besides only the ones focused on energy conservation.

In the present work, attempts will be made to compare rating systems, but also to discover if they truly make a difference when applied to a particular type of building.

CHAPTER 2. MANDATORY AND VOLUNTARY ACTIONS TO IMPROVE THE BUILT ENVIRONMENT

2.1 MANDATORY POLICIES AND LEGISLATION

All over the world, many governmental and non-profit agencies have embraced attitudes that pursue reduction of energy consumption in all commercial sectors.

To overcome barriers, federal and local governments have to prioritize their strategies for climate change mitigation, and policies of the type that encourage green practices have to be instigated and should aim at basic objectives (UNEP, 2009):

- Energy efficiency in building improvements including the building envelope and the operational aspects.
- Increment of energy efficiency of appliances to reduce energy consumption and at the same time reduction of cost in terms of production and consumption.
- Promote the use of renewable sources of energy instead of fossil fuels.
- Encourage energy generation and distribution corporations of energy to support the reduction of emissions within the building sector through demand side management that helps supervise and plan energy efficiency programs offered to costumers.

Energy demand can vary from region to region, and population growth rate can also make a difference; hence, policies help, because as a result of their implementation, there is an expectation of the reduction of energy consumption in developed countries. As far as developing countries are concerned, the National Bureau of Economic Research of the United States (NBER) predicts that energy demand will increase, because when the income of the poor increases, these households have a tendency to purchase more appliances or cars, therefore more energy will be needed to run them, as well as to manufacture them (Wolfram et al., 2012).

An EIA report in 2009 shows that as more income throughout the year entered different households, more square footage of the American homes had to be cooled and heated; therefore more energy use was required. (See fig. 1). Although it is interesting to observe that at the range of income between $59,000 and $119,000 there is a decrement, but then beyond that the square footage goes up again; this could be due to number of occupants and

their age.

Figure 1. VARIATION OF THE COOLING/HEATING NEEDS ACCORDING TO HOUSEHOLD INCOME AND SQUARE FOOTAGE IN THE UNITED STATES.

(Source: Energy Information Administration. Office of Energy Consumption and Efficiency Statistics, Forms EIA-457 A and C of the 2009 Residential Energy Consumption Survey)

As far as energy requirements is concerned, the International Energy Outlook of 2011 published by the IEA indicates that the tendency of growth of energy demand will be 20 percent through 2030 and, even when this forecast is somehow uncertain due to the elasticity of demand, it helps to predict what the future could be look like.

Therefore the data presented in fig.2 help understanding also why policies are needed mostly in developing countries because it shows that they have a higher tendency to use more energy as time goes by.

In this chapter we will only discuss a few of those polices, along with some regulations, since the case studies to be evaluated will be based on LEED and CASBEE, which are voluntary tools for the evaluation of green buildings.

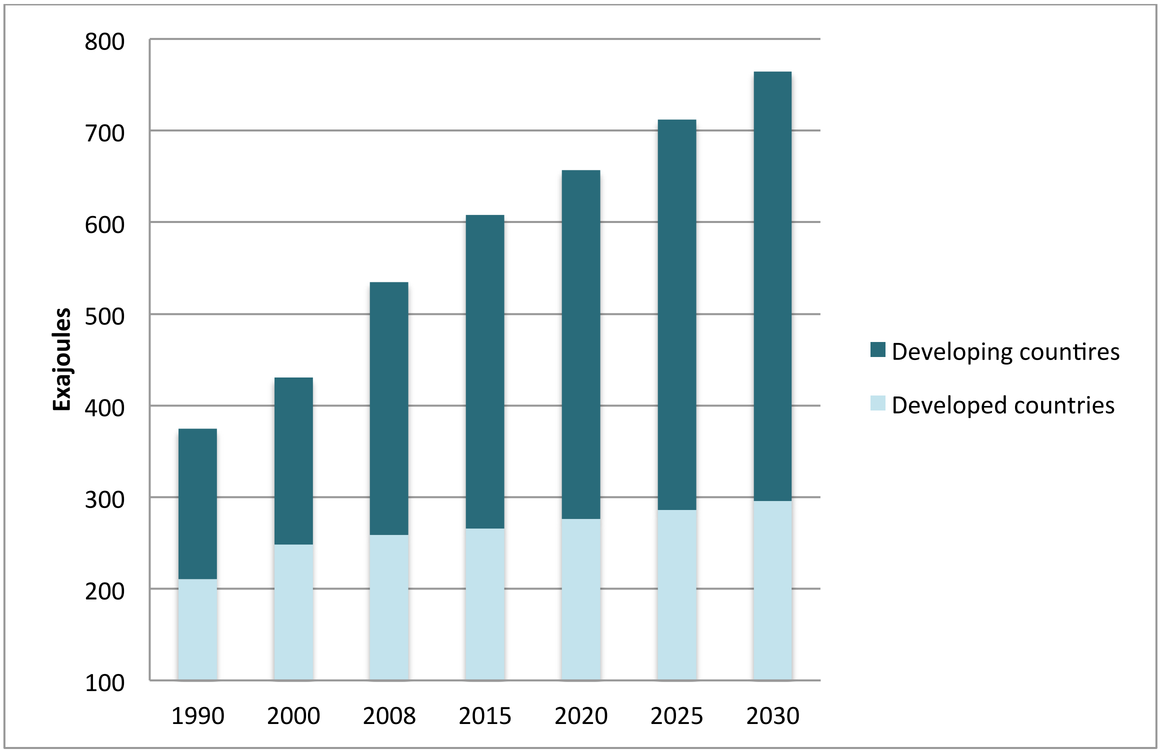

Figure 2. ENERGY CONSUMPTION YIELDS AND PREDICTIONS IN DEVELOPING AND DEVELOPED COUNTRIES.

(Source: Energy Information Administration. International energy Outlook of 2011)

2.1.1 Energy Performance of Buildings Directive (EPBD)

This very directive is pivotal for all the Member States of the European Union because it is inspired by the commitment of the member states in regards to climate change and the Kyoto Protocol's goals of 1997 in regarding to greenhouse gas reductions.

It is focused on reducing energy consumption and wastage reduction. The 2002/91/EC mandates that all the member states of the EU enhance their regulations on buildings and the development of certification schemes for those buildings. Following this directive, its recast 2010/31/EC adds the mandatory certification of new and existing buildings and mandates that by December 13, 2020, all new buildings must be Nearly Zero Energy

Buildings (NZEB), meaning that they should have a high energy performance and zero energy consumption, consequently producing zero emissions (CA-EPBD, 2011).

The precise actions of the directive are to inspect the HVAC systems, without the minimum requirement that boilers and air conditioners must be inspected without exceptions. The minimum energy performance must be defined by each member state, as well as the methodology of calculation per each country. The energy performance certificate (EPC) must be issued at different but specific levels during the existence of the building by accredited independent experts, and its display is mandatory for public buildings, while a very significant article mandates penalties for non-compliance. Certificates have a validity of ten years, and an administrative body is assigned by the building authorities to evaluate and issue them (CA-EPBD, 2011).

Evaluation of buildings according to the directive published in the Official Journal of the European Union (2010) uses the methodology suggested in the directive, and this includes aspects such as:

- Thermal capacity and bridges
- Insulation
- Cooling elements
- Passive heating
- Air conditioning systems
- Ventilation types
- Internal loads
- Passive solar systems
- Indoor thermal conditions

2.1.2 Energy Policy Act of 2005 (EPACT2005)

There have been many directives that back up the protection of the environment and public health in the United States; presidential executive orders are part of these implementations, and they range from regulations on atomic energy, clean air, clean water, occupational safety and health, toxic substances to endangered species protection, etcetera (EPA, 2012).

A remarkable one is the Energy Policy Act, which addresses the production of energy in the country. It was the result of the rise on the oil prices. The act focuses its concerns on three national issues (EPACT2005):

- Dependence of oil suppliers all around the world, meaning energy security
- Environmental quality
- Economic growth

It lays management goals to be accomplished by federal facilities. An analysis of the law would be very extensive, thus since the present paper is not focused on it, what the EPA has summarized about it may help to understand some of the law's aims (IEA, 2006):

- Energy efficiency. Where pursuance of energy conservation becomes mandatory for some component of the residential sector, some criteria must be followed in the incorporation of products and systems that make a reduction of the energy consumption. The parameters must fall onto Energy Start categories.
- Renewable energy. Purchase and use of energy produced from renewable resources are required, as well as actions similar to the installation of photovoltaic cells in federal buildings.
- Energy taxes incentives. Businesses that invest in energy efficiency and properties that use renewable energies will be granted tax credits (when purchasing energy efficient equipment such as water heaters, air conditioners, heat pumps, furnaces, windows, etcetera).
- Metering and Reporting. It mandates metering for all federal buildings and in that way it encourages reductions on the cost of electricity.

Those are some requirements among others.

At the same time, the U.S. Department of Energy has published the management program for Sustainable Buildings that explains some sustainable practices for operations and maintenance.

Besides the Energy Act, it is unfortunate to say that further development of policies on climate and energy has been challenging. This is mainly because energy policy in the United States is considerably associated with economic and political interests (Schreurs, 2004). Hence, finding the balance between climate policy and energy policy must be harmonized (Peterson and Rose, 2005). This can be achieved by:

- Reduction of mitigation costs by creating incentive-based policies.
- Equity promotion in regions, socioeconomic levels and generational groups.
- Make all the investors and participants interested and involved in the making of state policies.

2.1.3 Energy Policy in Japan

In Japan, the Ministry of Economy, Trade and Industry is in charge of the energy policy in the country and of the so-called four "E's":

- Energy consumption
- Environmental protection
- Economic efficiency
- Economic growth

Policies in the energy sector are needed because Japan has a dense population that, as any other, depends on stable supply of energy. Japan does not have local natural resources and imports around 84 percent of the total amount of its primary energy supply (Scalise, 2004). In the building sector there has not been a base regulation yet, but the government has created a system called "Eco-points" that aims to reduce consumer spending by limiting energy use, and incentives can be granted in order to use more efficient appliances (Vare, 2010).

The national commitment with the Kyoto Protocol is a 6 percent reduction of greenhouse gas emission. The previous goal has been envisioned to be fulfilled with the adoption of nuclear energy; this was the pride of the country, as they sought to make it their indigenous source. Unfortunately, not only has the "Not in My Back Yard" (NIMBY) attitude limited and discouraged this practice, but also the natural disasters that the country has been through since 2011. As a consequence of the earthquake and tsunami, it has been difficult to supply electricity, and that is why the focus on measures that reduce electricity demand has been intensified.

According to the Institute of Energy Economics (2012), mandatory energy efficiency standards should be enforced for all new constructed houses and buildings by 2020, and building materials should fit in within the environmental regulations that provide the adequate health protection to occupants.

Japan's Energy Conservation Act is the law that concerns the rational use of energy, and it has been modified six times. The last update, performed in 2008 includes strengthening measures for large residences and buildings to achieve energy savings (Energy Conservation Center of Japan).

The Energy Conservation Law enforces energy saving measures and it is the most reliable instrument in the country for these matters.

2.2 VOLUNTARY RATING SYSTEMS

Unlike policies and regulations, these are voluntary assessment tools developed all over the world. They consider location and regional governments' goals with the sole purpose of reducing the environmental impact of buildings.

Although in this study the focus will be on two assessment methods called LEED (Leadership in Energy and Environmental Design) developed by the Green Building Council in the United States and, CASBEE (Comprehensive Assessment System for Building Environment Efficiency) developed in Japan, there are many others, and in this section those will be mentioned briefly. It is important to note that all of them were at first designed to evaluate the energy performance of buildings and subsequently have developed a structure for green building design, construction and in some cases, operation and maintenance.

2.2.1 Leadership in Energy and Environmental Design (LEED)

In this part of the paper a very brief description of the LEED system will be outlined, given that in a later chapter the entire analysis of it will be done.

LEED is the most widely used system in the United States and has been adapted to different countries such as Canada, India and Mexico. The United States Green Building Council (USGBC) developed it in 1998 emphasizing its commitment of developing cost efficient buildings with achievable savings on energy.

Pursuing LEED certification is a voluntary action and design, construction and operation define the green building. Five main areas are evaluated on this assessment tool (Kubba, 2009):

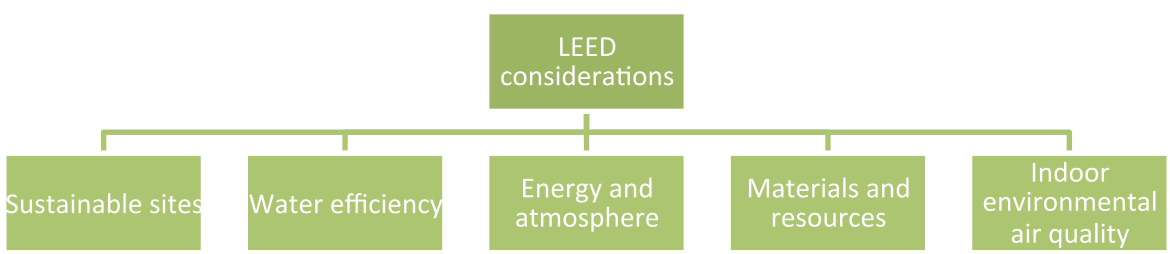

Figure 3. LEED AREAS OF EVALUATION

(Source: USGBC, 2010)

It is a system based on achievable credits distributed in the different areas which total can go up to one hundred plus ten bonus credits if the project succeeds on addressing regional issues related with the environment (LEED website, 2012).

According to the LEED website, the rating systems has a variety of applications according to the type of building to be evaluated:

- New construction and major renovations
- Existing buildings, operations and maintenance
- Commercial interiors
- Core and shell
- Schools
- Retail
- Healthcare
- Homes
- Neighborhood development

An aid to select the right systems is given by the USGBC with a Selection Guide of Rating Systems that helps with the decision making process at the same time.

As far as the evaluation areas and their requirements go, some of the credits are supported by various parameters or standards. According to Kubba (2009), they are developed by trade organizations or by the government. Some examples are cited here, although the list tends to be much longer:

- American Institute of Architects
- American National Standards Institute
- American Society of Heating, Refrigerating and Air conditioning Engineers (ASHRAE)

- American Wind Energy Association
- Department of Energy of the United States (DOE)
- Environmental Protection Agency (EPA)

2.2.2 Building Research Establishment's Environmental Assessment Method (BREEAM)

Developed in the United Kingdom but also used in the United States, it was established in 1990 by the Building Research Establishment (BRE). The environmental assessment method is used for buildings of the following types (BRE, 2011):

- Merchandising
- Offices
- Education
- Prisons
- Courts
- Healthcare
- Industrial
- Multi-residential

Although it is not easy to obtain the details of the tool unless one is a licensed individual, some of its targets are known and they easily relate to those corresponding to LEED (See fig. 4).

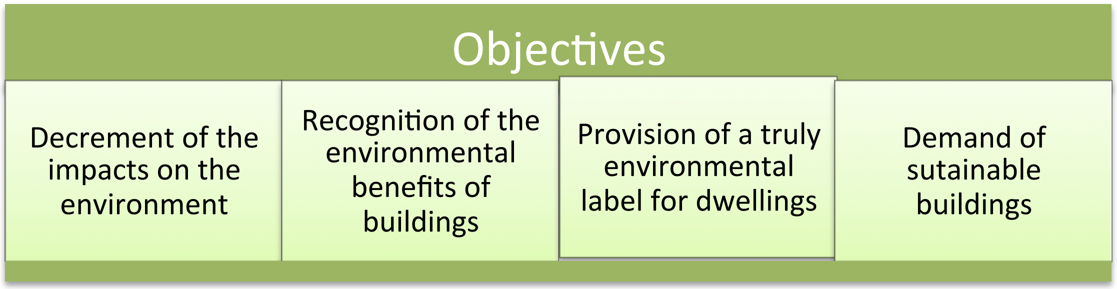

Figure 4. PURPOSES OF BREEAM

(Source: BRE, Technical Manual, 2011)

The steps to get an assessment are very simple. First of all, the type of the scheme that applies to the project must be chosen among community planning, construction and design of new commercial buildings, construction and design of new domestic buildings, existing buildings, and renovations. Step two is to establish contact with the licensed BREEAM assessor who will lead the organization with the registration process, getting certified and having a place in the green book live database.

As far as the designation of credits and their weight are concerned, the criteria to be evaluated are (BRE, 2009):

- Management - During monitoring, waste recycling, minimization of pollution and materials used
- Land use and ecology - Reuse of land or remediation of contaminated land
- Water - Reduction of consumption and metering
- Energy - Metering and efficiency of appliances
- Materials - Mitigation of asbestos, recycling facilities, reuse and use of sustainable local materials
- Heath and wellbeing - Through ventilation, humidification, lighting, adjustment of thermal comfort
- Transport - Emissions and provision of alternative transport
- Waste - Reduction or elimination

- Pollution - Renewable sources use, light pollution design
- Innovation (bonus opportunity)

The scoring and weighting is distributed among the categories mentioned above and the achievable rating result can be (Saunders, 2008):

Pass – 25%

Good – 40%

Very Good – 55%

Excellent – 70%

2.2.3 Green Star

The Green Building Council of Australia (GBCA) launched in 2003 the Green Star voluntary rating system, and it is relatively new compared with LEED and BREEAM. It has as its principal vision the achievement of sustainability and integration of green buildings (Saunders, 2008).

Although this assessment instrument is still developing the adequate methodology to be applicable in different types of buildings, it now evaluates projects such as buildings for education, healthcare, industrial, apartment buildings, offices, office interiors and, the most recent addition, communities (Saunders, 2008).

For the certification, a team of third-party assessors appointed by the Green Building Council of Australia will review the documentation, and credits will be validated or discarded after two rounds of examination (GBCA, 2010). In the second round, the project has an opportunity of resubmission to meet the criterion that were not found before.

With a score of 45 or above, and the evaluation of the Management, Indoor Environment Quality, Energy, Transport, Materials, Land use and Ecology, Emissions and Innovation, the GBC will give the award; the scale of rating can be seen in Figure 3 (Saunders, 2008).

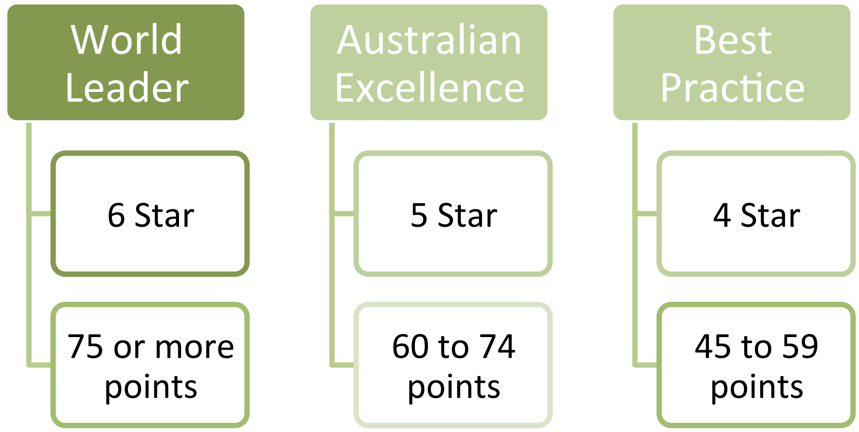

Figure 5. GREEN STAR CERTIFIED RATINGS

(Source: gbca.org)

2.2.4 Comprehensive Assessment System for Built Environment Efficiency (CASBEE)

As well as LEED, this instrument will be better explained later on, but here some brief information about it is presented. As far as is known, the potential of this rating system in different parts of the world is vast. This is because it represents the evaluation data of the quality building performance and the environmental load reduction (Fowler and Rauch, 2006).

Made public in 2004, the making of this tool had, since the very beginning, the idea of being very simple but at the same time having an approach to all types of buildings at their different construction stages. Another characteristic is that regional priority was given at the moment of the developing phase, so as to make it adequate for the Asia region (CASBEE). It embraces the entire life cycle of buildings, and evaluations are performed from the Pre-design phase, to the actual design phase and lastly the post-design stage.

CASBEE is made of four specialized assessment tools:

CASBEE for Pre-design (still unreleased)

CASBEE for New Construction

CASBEE for Existing Buildings

CASBEE for Renovation

At the same time CASBEE offers options for detached houses, temporary constructions, heat island effect, urban development and in a broader sense, cities.

Fowler and Rauch describe the way of examination CASBEE uses as two categories denominated as Q (quality) and L (Load) where:

⇒ **Q** represents the built environment quality and assesses those improvements in the building that benefit the occupants and the virtual surrounding space, and it is divided into:

Q1- Indoor environment; This refers to noise and acoustics, thermal comfort, lighting, illumination and air quality.

Q2 - Quality of services, in terms of functionality and usability, amenities, durability and how flexible and adaptable they are.

Q3 - Outdoors environment site, preservation of ecosystems, and outdoor amenities.

⇒ **L** stands for the build environment load evaluated, which is all about the aspects with environmental impacts beyond the virtual surrounding space, meaning the public property around it. The types are:

L1 – Energy, evaluation of thermal load, use of natural energy, and efficacy of systems.

L2 - Resources and materials, involves water conservation, recycled materials, sustainable wood, and low heath risk materials.

L3 - Off site environment, which refers to pollution of the air, noise, odors, blocking of the sunlight, heat island effect and on local infrastructure.

The indicator used for the environmental labeling is called "Built Environment Efficiency" (BEE) and it is a relationship between Q and L:

BEE=Q/L

BEE results then, into a gradient plotted on a graph of L vs. Q, and a building would be more sustainable when Q is higher while L decreases. This will be explained in detail in Chapter 4.

2.2.5 SBTOOL

The SB method provides a clear distinction between guidelines for design features and operating strategies, and then performance factors. It is carried by the non-profit organization International Initiative for a Sustainable Built Environment (iiSBE).

The principles of this tool focus on issues related to performance, either potential or actual. The iiSBE explains that the scoring process is comprised of a group of comparisons among the characteristics of the building and the national or local references of a practice that can be minimally accepted, show a good or best practice.

It is a generic system, a product that offers a main structure for building performance assessment the can be used by third parties in order to develop rating systems, or be considered as a toolbox for the assessments (iiSBE).

SBTool philosophy is to be adapted to local conditions to achieve successful results. It covers many building aspects related with sustainability and green issues (Fowler and Rauch, 2006). The basic framework covers many issues related to sustainability of buildings:

- Site location, available services and site characteristics
- Site regeneration and development, urban design and infrastructure
- Energy and resource consumption
- Environmental loadings
- Indoor environmental quality
- Service quality
- Social, cultural and perceptual aspects
- Cost and economic aspects

Each stage has a minimum, medium and maximum scoring achievable depending on the stage in which the assessment is applied: redesign, design, construction or operation.

The weighting system is based on the following factors (Larsson, iiSBE and Macias 2012):

a. Extent reached by the effect

b. Duration of the effect

c. Intensity of effect

d. Importance of primary system directly affected

e. Regional adjustment, which gives authorized third parties the ability to adjust the score factors derived from the multiplication of a*b*c*d up or down a maximum of 10%.

Overall all the rating systems described in this chapter have similar methodology and concern, if not the same, and similar aspects of the relationship between buildings and environment. This analysis was made with the purpose of creating a familiarity with the methodology towards green buildings certification.

3.3 ENVIRONMENTAL PERFORMANCE PROGRAMS

This concept is meant to encourage green building design as well, and it is supported by guidelines or programs that lead the path to this concept. A particular about this model is that the programs do not assign specific ratings (ASHRAE, 2006), but still are pro-environment.

The ASHRAE Green Guide published in 2006 is meant to be one of these schemes. It is also voluntary; it sets performance requirements for buildings and can be helpful when compliance with different green codes is needed. The latest are also minimum requirements to achieve energy efficiency in designs and constructions (DOE, 2010). Therefore, these parameters are meant to aim to HVAC&R systems and their effective functioning.

CHAPTER 3. DECONSTRUCTING LEED

There are many rating systems that have been developed in different countries, some of them, like the ones mentioned in the previous chapter, have become very popular and their implementation is believed to be highly efficient due to the methodology they use to rate how buildings and the built environment affect our natural surroundings. Therefore even when the Leadership in Energy and Environmental Design has proved to be trustworthy, many experts in the matter have criticized it extensively, and even the USGBC has admitted that LEED is not perfect; however, they are always trying to develop new methods and keeping it up to date with new technologies and environmental concerns.

The LEED rating system has undergone international adaptations such as LEED Canada, LEED India, and LEED Mexico. It has been successful, and the most recent version considers a new feature called regional priority, giving more chances for the tool to be more fitting in the different countries in which it is applied.

The latest, and current, version of LEED is LEED v.3.0 with recent updates addressed from LEED 2009, developed after its previous versions, and whose certification process is done by the Green Building Certification Institute. It is based on ISO (International Organization for Standardization) standards in order to increase productivity and quality but also uses those from the American Society of Heating, Refrigeration and Air (ASHRAE) applicable to certain products and appliances.

The LEED certification process begins right at the moment the design process does. However, the first step is the registration with the USGBC via online to make the process easier and paperless. From here evaluation of the credit categories arises to assign the weighting of credits, but before that, some prerequisites are obligatory and make sense with the purpose of each classification. If the prerequisites are not to be met, then the project cannot be conceived or even started.

3.1 MINIMUM PROGRAM REQUIREMENTS (MPR)

The MPR list all the basics that a project must comply with in order to be eligible for certification. They seek to provide guidance to costumers, to make LEED trustworthy and to reduce any complication that could be present at the moment of certification. They are applicable for all the LEED categories as a baseline and they are the following (USGBC, 2009):

a) Must comply with federal, state and local environmental laws applicable.
b) It must be a finished and permanent construction.
c) Site boundary must be realistic; invasion of land should be avoided if this is not part of the owner of the LEED project. If land is disturbed by the project it must be included in the site boundary.
d) Must comply with a minimum floor area requirement of one thousand square feet for all the categories except Commercial Interiors and Retail, which are expected to have a minimum of 250 square feet.
e) Minimum occupancy rates defined by the annual average of full time equivalent occupants.
f) Obligation to share energy and water usage data correspondent to the entire building for all systems with USGBC and the GBCI by providing information on regular basis.

Although these MPR might be seen as evident for any candidate, LEED claims that such specifications must be made so as not to create controversy of different points of view.

3.2 THE ASHRAE STANDARDS

These certainly have a strong influence on the credit categories, and this will be an important item when analyzing setbacks, if such are to be found.

LEED relies on ASHRAE to help define what is going to be asked from a project when pursuing certification. Therefore it considers the following references:

- Testing Ventilation Air-Cleaning Devices for removal of particles
- Setting thermal environmental conditions for occupants
- Acceptable indoor air quality
- Energy standards for buildings
- Energy savings

The above are among the most important (Kubba, 2009). They are useful when it comes to choosing products and methodologies that lead to what the rating system requires, but for the most part they do not help measure energy units or volumes of emissions.

3.3 PREREQUISITES

These will be observable when looking at the checklists for each category and type of building. Depending on the credit category, some prerequisites are necessary and compulsory. Without them it would not make sense to even try to evaluate the area due to the fact that they are related to the principal issues that the category could potentially trigger.

3.4 AREAS OF PERFORMANCE

The areas that the system assesses were mentioned earlier but now details about each category will be given. In order to have a holistic building approach that can lead a project to sustainability, strategically all the areas should perform well to achieve a good certification, but also to be able reach the goal of extending the green buildings network (USGBC, 2009).

3.4.1 Sustainable Sites (SS)

Site selection and its development must be carefully done, but mainly in a sustainable way.

A primary objective for those who participate in the project should be the avoidance of developing a new site in land that has not undergone any anthropogenic alteration.

The reason why this category has importance is that when undeveloped lands are disrupted, the negative effects are clearly seen in the ecosystems and waterways. What is strongly emphasized here is that, when possible, the members of the project should choose a site that offers the chance of urban and brownfield development, and during the design all disturbances to the ecosystems around the site should be minimized.

A remarkable consideration in this category is the idea of integrating transportation options other than making the occupants of the building drive their car everyday; carpooling should be strongly encouraged. Having preferred parking can reward those who have chosen to use cars that use alternative fuels.

Some other strategies can also be convenient to help reducing the heat island effect, often as simple as using light colored roofs or green ones. Reduction of light pollution is also part of this segment, and it fits here because if a building is too bright at night, it causes discomfort to neighbors, so intensity of the light should be controlled.

3.4.2 WATER EFFICIENCY (WE)

Water savings are essential in a green building because it is the resource that is most used and most valuable. The intelligent use of water can be complicated because it has to do with its availability; those who have lacked its provision can understand better why it is important to preserve it and take care of it, while those who never had to go through their daily activities without it tend to be careless and unappreciative of it.

Regardless of the situation, water efficiency can be achieved in many ways. First, it has to be understood that water has a function of helping complete a purpose, be it showering, dish washing, etcetera, and that sometimes its use can be more than what is really needed. This is more oriented to the conservation of water.

Water efficiency seeks the reduction of waste without limiting use, and the main player to help achieving this is the consumer more than any new and sophisticated appliance in the market. Mainly, a conscious use of it is always encouraged.

In terms of appliances and systems, plumbing technologies should be incorporated, and leaks must be avoided; proper use of dishwashers and washing machines with full loads must be made, etcetera. Techniques to manage storm water to minimize pollution and sedimentation of soils can be also helpful, as well as stormwater harvesting and its reuse in non-potable applications.

3.4.3 Energy and Atmosphere (EA)

Energy efficiency is one of the most interesting credit categories due to the vast consumption of energy by buildings, which was mentioned in Chapter 1. What makes this phase quite the challenge to overcome is the reliance on fossil fuels and their byproducts, and therefore the consequences of the growing demand for energy that is faced nowadays.

Promoting the application of strategies that reduce energy consumption is the goal, and credits will be given to those that succeed in this matter, as well as for the use of renewable energy sources.

Heating and cooling systems of the right size for the building should be used and should take into consideration how efficient the envelope of the building is. At the same time the use of chlorofluorocarbon- and hydrochlorofluorocarbon-based refrigerants has to be eliminated due to their great contribution to the ozone depletion.

A very easy alternative to gain credits is to use appliances that are certified under ENERGY STAR labeling, which gives recognition to products that contribute to energy savings, so minimizing their electric loads is also covered.

Full attention to the building envelope should also be given in the opaque and transparent elements.

3.4.4 Materials and Resources (MR)

The selection of materials is a complex category with so many options in the market and standards to be met. The amount of waste and utilization of material in buildings can be significant, and these two can happen during construction and operation, so the importance of products and materials that have been made in a sustainable way is outstanding.

Recyclable and rapidly renewable materials can be granted with credits, especially if they are available within the local or regional community, not to mention that certified wood is an addition that cannot be missed.

3.4.5 Indoor Environment Quality (IEQ)

Any building environment should provide good indoor air quality, and this can be done by targeting the sources, which in most cases are found inside the building itself. The importance of this (as it was mentioned in Chapter 1) arises from the amount of time spent indoors, and which exacerbates influences of exposure to toxic materials, high concentrations of carbon dioxide, or to mold, lead, asbestos, etcetera.

Optimum lighting, healthy indoor air quality and thermal comfort are essential provisions. Good ventilation systems can be instrumental for these purposes, so as to provide environmental tobacco smoke control, in addition to HVAC systems that meet the requirements of the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). Paints and coatings free of lead and volatile organic compounds, etcetera assure healthy indoor air quality.

3.4.6 Innovation and design process (ID)

When a project innovates in strategies that improve the building's performance other than the base categories, it can be rewarded with bonus credits. New technologies are available everyday, so those who invest time and effort updating their projects will be rewarded.

3.4.7 Location and linkages

This category is only for LEED homes, as well as those explained in sections 3.2.8 and 3.2.9. Location and linkages is about the access that homes have to services, public transportation, grocery stores, and etcetera; in this category, only bonus points are achievable. All these measures are taken in order to avoid the use of car and energy by driving long distances for what can be considered daily chores and activities.

3.4.8 Awareness and education

According to the checklist, this category rewards the knowledge that the homeowner can pass to the tenant in terms of operation of the building since the green features could have particular ways to be managed. Basic operation is the base, and then what will give the credits is the training and creation of mindfulness among the public.

3.4.9 Regional priority (RP)

The motivation of this classification is to tackle geographically specific environmental issues. One bonus credit can be acquired here when four to six credits are completed. Depending on the type of project and its location, LEED maintains a database of suggested actions that can help grant credits, but only in the United States. If LEED is being applied somewhere else, then the team must research these priorities.

3.5 THE PROCESS TOWARDS LEED CERTIFICATION

Once all the requirements have been taken into consideration in within the project, then the members of the team must prepare for the submission on their documentation and begin the five-segment process explained in Table 1 (USGBC, 2012).

Table 1. PHASES OF THE LEED CERTIFICATION PROCESS

Phases	Description
Step 1	Registration of the project It is advisable that it should be done during the design phase. The submission is made online through the USGBC and it only requires the basic information about the project like surface area, location, building type, and etcetera. Early registration is a positive thing to do because it allows access to helpful tool and establishes communication with the GBC. A fee must be paid according to the type of building that is being registered and when a project is granted LEED Platinum certification the fees are waived.
Step 2	Integration of the LEED requirements Prerequisites have to be met in all cases to achieve certification because they sum up a minimum number of points.
Step 3	Technical support access When a project is registered, the members have access to two request for Credit interpretation Ruling that help understanding credit in a better way, or the can also obtain help in any technical or administrative questions.
Step 4	Documentation of the project for certification The application process is composed of two phases: a preliminary submission for revision, and a final submission. These submissions go further ahead than the registration of the project and are more detailed, a fee for certification in the design and construction phase will finish the process. The technical review assesses the status of the targeted credits and when the

	resubmission is done the credits are awarded. The forms that support each prerequisite and credit must be contained here.
Step 5	Certification Receipt The Final LEED Review report is done after the second submission and it delivers the final status of the credits allocation and the level of certification. Appealing is a right that the project members have but they must pay a fee as well and submit a series of documents along with it.

(Source: USGBC, 2010)

To ensure that a project has covered all the points required, checklists are provided for each type of building and its specific purposes.

To support the credits earned in each category, the USGBC uses standards that are continually developed and updated by specialized associations, governmental agencies or organizations whose one and only mission is standardization, such as ISO. It is then that all the credits must fit in order to be given the necessary points.

The evaluation of points is done with different types of software that have been adapted to LEED such as Lorax, which assists with the tracking of points, or TRACE which calculates energy loads. In this project it was not possible to find more information about the accessibility to the software, but based on online searches it was found that the software is too complicated to understand, to run and to decode. Once this is overcome, the simulations or predictions are reported for evaluation.

3.6 THE RATING SYSTEMS

As mentioned previously, the rating systems are:

- New construction and major renovations
- Existing buildings, operations and maintenance

- Commercial interiors
- Core and shell
- Schools
- Retail
- Healthcare
- Homes
- Neighborhood development

But regardless of knowing the purpose of a building, the project members should make sure that they are submitting it under the right rating system.

A very helpful tool to allocate the project is the guide to select rating systems that the USGBC has published; this document helps understand which LEED rating system corresponds to a determined project so it can be registered.

LEED Schools and LEED for Healthcare do not apply because of their peculiarities; they must always be under their own classification.

The methods of selection are:

- Rating systems chosen by the construction type, either for those that are new constructions or major renovations, and an entire provision of interior equipment.

  Five rating systems apply for Complete Constructions:
  - LEED for New Constructions and Major Renovations
  - LEED for Schools
  - LEED for HealthCare
  - LEED for Retail (New Construction and Major Renovations)
  - LEED for Homes

Core and Shell Constructions Major Renovations, meaning on the exterior shell and electrical and plumbing units:

- LEED for Core and Shells

Businesses renewing their Interior Spaces completely, or at least 60 percent of the certifying gross area:

- LEED for Commercial Interiors
- LEED for Retail: Commercial Interiors

If existing buildings are having little improvements done:

- LEED for Existing Buildings: Operation and Maintenance

• Selection based on space usage type:

- LEED New Construction and Major Renovations:
  For buildings that do not serve the purposes of K-12 educational, retail or healthcare uses and, residential buildings that are more that 7 stories. K-12 is the so-called Basic Education Program in the United States that goes from Kindergarten to Senior in High School.
- LEED Schools:
  Learning spaces on K-12 school groups and non-academic buildings in school campuses.
- LEED Healthcare:
  For buildings where medical practices are carried out.
- LEED Retail for NC and Major Renovations and, Commercial Interiors:
  For buildings or interiors where products or commodities are sold
- LEED for Homes
- LEED for Commercial Interiors

When the cores are not use for commercial purposes.

3. 7 THE AWARDS AND WEIGHTING OF THE CREDITS

Once the credits have been weighted according to the standards of each category they are added up. Their distribution is a share of human and environmental benefits determined according to their outcome on each credit that could be related to global warming, fossil fuels use, greenhouse gas emissions, indoor quality, and air and water pollution (LEED, 2009). These outcomes, called impacts, are then measured, and the total of allocated points in the credits is the so-called credit weighting.

For the LEED 2009, the EPA possesses the Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI) that, according to the federal agency, assists in the determination of environmental impacts by categorizing these influences, how they store in the environment and their life cycles then, the endpoints (Bare, 2002).

The system is based on a scale of 100 points and 10 bonus points can be earned when innovation and design and regional priority have been reached, as mentioned before in the description of each assessment category. This is done in order to address geographically environmental issues in the United States and all over the world. Therefore the awarding goes as follows:

TABLE 2. LEED Certification Levels

POINTS ACCUMULATED	AWARD
40 to 49	Certified
50 to 59	Silver
60 to 79	Gold
80 or more	Platinum

(Source: USGBC, 2010)

CHAPTER 4. ANALYZING CASBEE

Like LEED, this assessment method evaluates the environmental performance of buildings and the built environment, and it makes regionalization of the site a priority. When developed, four codes were meant to be basic components of it (CASBEE, 2010):

a) The structure of the tool was meant to give recognition to buildings because that works as an incentive for designers, architects, engineers and other professionals involved.
b) The instrument aimed to be easy to understand.
c) An extensive range of building types could be evaluated by the system.
d) The scheme had to focus on Asia's environmental issues, specifically the ones in Japan. At the same time, the different climates in the region were considered, as Northern Asia can go from extremely cold and humid temperatures to concentrated rainfall in the summer in the Central Asia, until reaching tropical and humid weather in the Southern part (climatezone.com, 2004).

The system has been designed to deliver a variety of benefits in the private sector and to be applied at the governmental level. The first one refers to environmental labeling, pursued so as to give more value to the assets of a company, which is a similar purpose to that of LEED; however, CASBEE also includes the diagnosis of the environmental performance, which helps with the design of operation monitoring and upgrading buildings' systems so as to achieve energy savings. For administrative purposes in the business sector, the tool is an option for office buildings, as they should be able to use it to improve their environmental performance and indoor air quality, all these goals being driven by a tax incentive.

4.1 THE CASBEE ASSESSMENT

The way that all the CASBEE tools make assessments is ruled by three methods.

A full examination of the lifecycle of the building has to be done. This is a comprehensive examination throughout its life cycle, which is followed by the evaluation done to the environmental quality (Q) and load (L) (mentioned previously in Chapter 2); lastly, the Built Environment Efficiency Indicator (BEE) will provide the overall assessment rate (CASBEE, 2010).

Previously it was explained what function quality (Q) and load (L) have in the rating system and their subdivisions, figure 6 is meant as quick reference to them again:

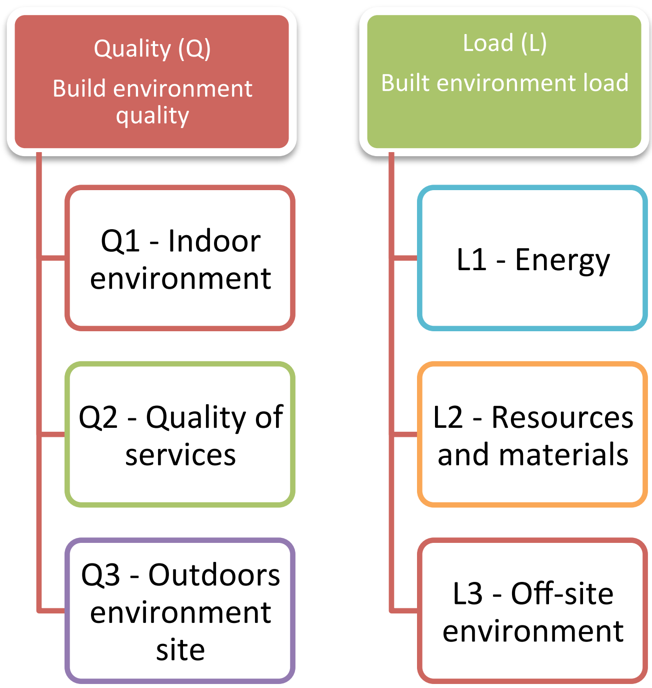

Figure 6. CASBEE ASSESSMENT CATEGORIES

(Source: http://www.ibec.or.jp/CASBEE/english/backgroundE.htm)

These two elements Q and L are both related to the internal and external spaces, which are assessed by CASBEE, and at the same time a division in between the spaces exists. In the system, there exists a hypothetical enclosed space called "hypothetical boundary" and it is the link of the limits of the building site with the outer or surrounding space.

Owners, engineers, designers and architects have control over the so-called on-site space and what is beyond is no longer manageable by those involved with the building (See Figure 7).

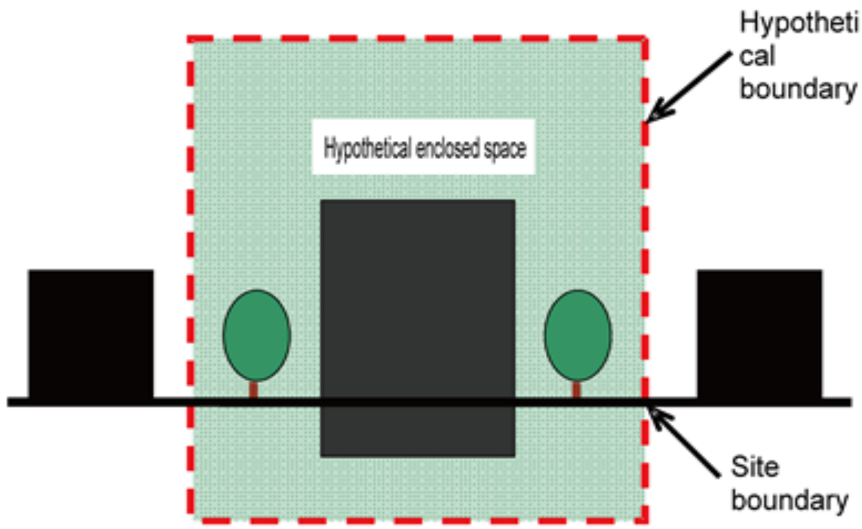

Figure 7. CASBEE CONCEPT OF THE SPACES EVALUATED

(Source: http://www.ibec.or.jp/CASBEE/english/backgroundE.htm)

Therefore, going back to Q and L, it is important to understand that the environmental loads are considered as negative environmental impacts that can be reflected on the off-site space, meaning past the boundary, and they affect what those are that are beyond it, like public property, environment and individuals. On the other hand, the enhancement of the environmental performance inside the enclosed space delivers an improvement in regards to the living amenities of the occupants.

All of the above background helps understand how BEE is represented. It describes how the sum of all the Q elements has an effect, either positive or negative, on L. The concept is based on the definition of environmental efficiency being an outcome of the value that product and services have per unit of environmental loads.

As far as the fields assessed are concerned, they are four, and they provide help categorizing the Q and L in their different groups. The subjects are:

i. Energy efficiency
ii. Resource efficiency
iii. Local environment
iv. Indoor environment

BEE then is the main concept of CASBEE and what makes it particularly original is its ability to present in a simple and understandable way of the performance.

$$\textbf{BEE (Built Environment Efficiency)} = \frac{\textbf{Q (Built environment quality)}}{\textbf{L (Load environment quality)}}$$

The results are expressed in figure 8.

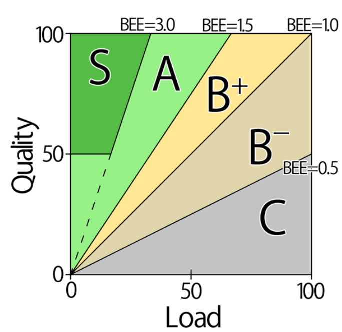

Figure 8. CASBEE Ranking System Based On The Built Environment Efficiency (BEE)

(Source: CASBEE Website)

Where the values S, A, B+, B- and C are the ratings and they are denominated as:

Table 3. CASBEE CERTIFICATION DEGREES

RANK	ASSESSMENT	EXPRESSION
S	Excellent	5 star
A	Very Good	4 star
B+	Good	3 star
B-	Slightly Poor	3 star
C	Poor	1 star

(Source: CASBEE Website)

The calculations are all run in Excel-based software that facilitates entering data, and with the already entered reference data calculates loads and their reduction.

4.1 BEYOND THE BEE FACTOR

In the most recent version on CASBEE a distinctive evaluation has been added, it is not unique because of what is assesses, but because it considers a fundamental indicator of climate change and energy production side effect. This is the Life Cycle of Carbon Dioxide (LCCO2) and is meant to support the low carbon emissions by yielding total CO_2 releases (Kiyoung, 2012).

According to their website, CASBEE has developed a tool on a spreadsheet that makes the evaluation of CO_2 emissions very simple. LCCO2 emissions are evaluated according to those measures taken to achieve CO_2 reductions, and their comparison with a reference building that has performed according to the Energy Conservation Law of Japan (CASBEE, 2008).

This assessment awards from 1 to 5 so-called Green Stars that are the outcome of a combination of emissions and BEE evaluated as a whole. The rate of emissions is matched and compared with other emissions levels corresponding to a reference that has complied with the Japanese Energy Conservation Law (CASBEE BROCHURE, 2011).

The scale of the Green Stars is as follows:

1 star – LCCO2 > 100% (non-energy efficiency)
2 stars – LCCO2 < 100% (energy efficiency standards are satisfied)
3 stars – LCCO2 < 80% (building achieved 30% energy savings during operation)
4 stars – LCCO2 < 60% (building achieved 50% energy savings during operation)
5 stars – LCCO2 < 30% (zero energy consumption during operation)

4.2 THE ASSESSMENT TOOLS

The available CASBEE instruments are called CASBEE Family and they evaluate life cycles related to buildings. The cores of the tools are four basic tools that aim to evaluate the construction process at different stages of the architectural design process.

It is important to be familiar with the stages to be able to understand the different CASBEE models and remember that the labeling is given at the end of each stage of building's lifespan cycle. The steps therefore are:

I. Pre-Design

At this stage the setting requirements of building a dwelling, such as site location, social, cultural and natural circumstances are studied so as to figure out a design, taking into consideration at the same time all policies applicable. It is about planning and simulating processes.

II. Design

The building concepts are assessed in all their aspects because this provides information about their ecological, social, technical, esthetics and economic aspects. It includes examination of the preliminary design, its execution and completion.

III. Post-Design

The design is put in run-through but subjected to verification of its life cycle and sustainability level. Improvements can be done, and the process flows back to the design phase.

4.2.1 THE FUNDAMENTAL TOOLS

As mentioned above, they are four. In this section they will be explained and detailed:

a) CASBEE for Pre-design (Planning)

Although still under development, the scheme is done in order to assist the construction team members with the prediction of environmental impacts that the project could entail.

b) CASBEE for New Construction

Allowance to improve the BEE value is an advantage in this type of construction since the design process can be checked over and over again, because assessments are done according to the specifications of the design. CASBEE for NC predicts assessments based on the design terms that are put to test for three years. After that, these results lose validity and the construction has to be evaluated again, this time with the following tool.

c) CASBEE for Existing Buildings

Operation records after at least one year of functioning are used to evaluate the buildings if it has not been assessed before.

d) CASBEE for Renovation

Since many old buildings exist in Japan, opportunities are vast for this assessment. Proposed renovation action can be derived from here, and furthermore, monitoring can be added in the plan.

4.2.2 APPLYING CASBEE ON DIFFERENT TYPES OF BUILDINGS

CASBEE, just like the LEED rating system, has among its priorities to ensure the adequate allocation of a rating system applied to the corresponding building; it is indispensable to do so because the evaluation is narrowed down to cover all issues related. However, CASBEE has added to its scheme a broader category that even seeks to reduce the heat island effect and evaluate entire cities' environmental performance.

Following is the listing of buildings and systems that can be weighed by CASBEE:

1) Detached house (CASBEE for Home)

   In the assessment, not only is the house evaluated, but also outdoor space and home appliances, and therefore information is given to the occupant to figure out environmental strategies at the design stage.

2) New Construction (CASBEE-NB)

   Getting a new construction ranked can increase its BEE value. In this method, the assessment is done according to the terms on which the design is based and how it forecasts the performance of the building.

   CASBEE has put this system under its short version category because the assessment should not take longer than a week.

3) Existing Buildings (CASBEE-EB)

When a building has operated for at least a year, using the records of the functioning is the approach the assessment uses. CASBEE for detached houses is used for this purpose.

4) Renovations (CASBEE-RN)

It is another brief version like the one for new constructions, where the main objective is to achieve energy efficiency through adequate planning at the beginning of the project. Another advantage of the short version is the capability to submit and prepare the documentation to government offices in a reasonable amount of time.

5) CASBEE for Temporary Construction

The LEED certification does not take into consideration this category, but CASBEE has made clear its purpose to evaluate short-term use constructions. It is based on CASBEE-NB and it is planned to be applicable to structures made for a purpose of hosting events for a short period of time, for example.

6) CASBEE for Heat Island Relaxation (CASBEE-HI)

CASBEE has put the attention on the Heat Island effect by handing out a meticulous assessment about the quality of the measures taken to fight it in major urban areas. A particular about this category is the focus put on the outdoor temperatures and the load discharged to the environment that contribute to the heat island effect; hence, efforts are constantly put on the performance of buildings to lighten the effect.

7) CASBEE for Schools

As in LEED, the range of schools evaluated are elementary, junior high and high schools (which in the US is called K-12). The field of application is vast in Japan since many schools are buildings over 50 years old.

8) CASBEE for Urban Development

CASBEE has approached urbanism and green building as well as LEED certification. The core: community efforts to improve the environmental performance of an urban area, since population concentration is too dense. General common measures are taken by all the properties owners so as to achieve energy savings.

9) CASBEE for City

   Unlike LEED, the significance of assessing cities is major for CASBEE, as the dimensioning can be challenging. It is a great scale evaluation, and this study can guide citizens going through an understanding about the environmental conditions they live in and what they can do to improve them. It is a great strategy to get individuals involved with the movement, because through administrative incentives, environmental problems can be addressed, and more attention is paid when a reward is expected.

As it has been mentioned above, CASBEE is very similar to LEED in terms of final purpose, but the methodology along the certification path is placed differently and definitively stricter. It is important to mention that CASBEE assessments are done by individuals who have been trained by the CASBEE organization itself.

CHAPTER 5. LEED CASE STUDY: CONSTRAINTS AND ITS CASBEE COMPARISON

5.1 THE PROJECT

To be able to understand the differences between LEED and CASBEE, a case study is to be analyzed and re-assessed for its overall performance. It must be mentioned that this is only a theoretical consideration, given that the correspondent software of each tool is only available for those accredited or trained individuals on the capability of running evaluations; however, by doing this the constraints of the system can still be allocated.

The case study taken as an example in the present work is the one submitted by Arizona State University (ASU) regarding the certification of its Biodesign Institute building. The construction, located in Tempe, Arizona, was built in 2005, and the actual certification process took place during the occupancy phase, being completed by the end of the year 2008. This is a large complex with a surface area of 74,300 m^2, and consists of two buildings designed as A and B occupied by around 600 employees; said buildings enclose offices and laboratories. For this appraisal we will only focus on Building A and its scorecard.

It is important to mention that this assessment was done in reality with the LEED-New Construction Version 2.2 and Gold Certification level was granted to the structure. Nevertheless for this document, the scorecard was adapted to LEED version 2009 for New Construction since it is the most recent update and its parameters applicable to new buildings and major renovations (LEED, 2009).

An equivalent scorecard can be found in Appendix 1 to reference the proportionally achieved total points and their corresponding credits. Appendix 2 corresponds to the checklist that explains each credit's description and value.

This simulation assessed that Building A would get LEED Gold certification for New Constructions in the 2009 version.

The Arizona building, according to the report done by the Western Regional Climate Center, is exposed in the winter to average temperatures of around 21 degrees Celsius, and in the summer these fluctuate to around 40 degrees Celsius. Rainfall is mostly common throughout July until September, since this is a semi-arid zone. As mentioned previously, knowing the climatic conditions of the site is necessary because the design and construction are more successful when adapted to these surroundings.

Image 1. THE BIODESIGN INSTITUTE BUILDING (FRONT PART OF BUILDING A)

(Source: www.biodesing.asu.edu)

Image 1 can help dimensioning the building, and some of its green features are visible, but most importantly the size and how complex it can be to make such construction to be energy efficient is made evident.

Financially speaking, the project team directors and the university staff agree on the statement that LEED only added from 3 to 5 percent extra to the total cost. Larry Lord (2010) as an architect with vast experience in the field believed that the prices could be contained because of the variety of products on the market, and because early design and calculations prevent other expenses that might be present when the project is in a more advanced construction phase.

Another factor that did not stretch the budget was that Building A does not have photovoltaic cells. They are expensive, and if one is to consider them in a project, they have to be incorporated from the very beginning so the payback period is visible without any other alteration.

5.2 THE VARIOUS WAYS USED TO ACHIEVE POINTS - WERE THEY CORRECTLY ASSESSED?

On the ASU website dedicated to the Biodesign Institute building, it is possible to find the approach of the project team, which led to the addition of points in the various categories.

This section is dedicated to the study of the techniques that the team project implemented. However, when the building was planned LEED certification was not even contemplated, but since the prerequisites are in compliance with building codes, they had to be covered regardless of the certification. They basically involved control of erosion of the land and avoidance of airborne dust during the construction period.

In spite of compliance with the building codes, LEED has given some additional recognition to the projection team because since the very beginning, this building was envisioned to fit into the sustainable range, which makes us think that from now on, all buildings should always be directed to achieve the same result.

5.2.1 SS Credit Category

Community connectivity to basic amenities was encouraged and implemented, and it seems fitting, as the building is located in the middle of the desert. Therefore, the layout drawing process ensured that the building was located in a convenient place where multiple services and facilities can be reached on foot within the criteria radius.

The establishment's design was meant to take advantage of the already available transportation setup from the very beginning, and it opportunely overlapped with the construction of the new light rail system in the city. Now with the LEED certification and to gain points, ASU offers unlimited transportation on the campus, and that is the way to encourage the use of alternative transportation; alternative fuel stations have been set to recharge electric vehicles as well, and bicycle use is promoted with the suggested paths on the LEED guide. By the same token, parking capacity was not added to that provided already by the campus, so the project itself limited it.

Because the building was situated in a Greenfield site, development has been accomplished by introducing plants native to the Sonoran desert, and maximization of the open space was largely achieved with an 80% of the total land area (Image 2). The storm water management system helps capture water that is used for landscaping. Water is collected from the roof and roadways and then redirected.

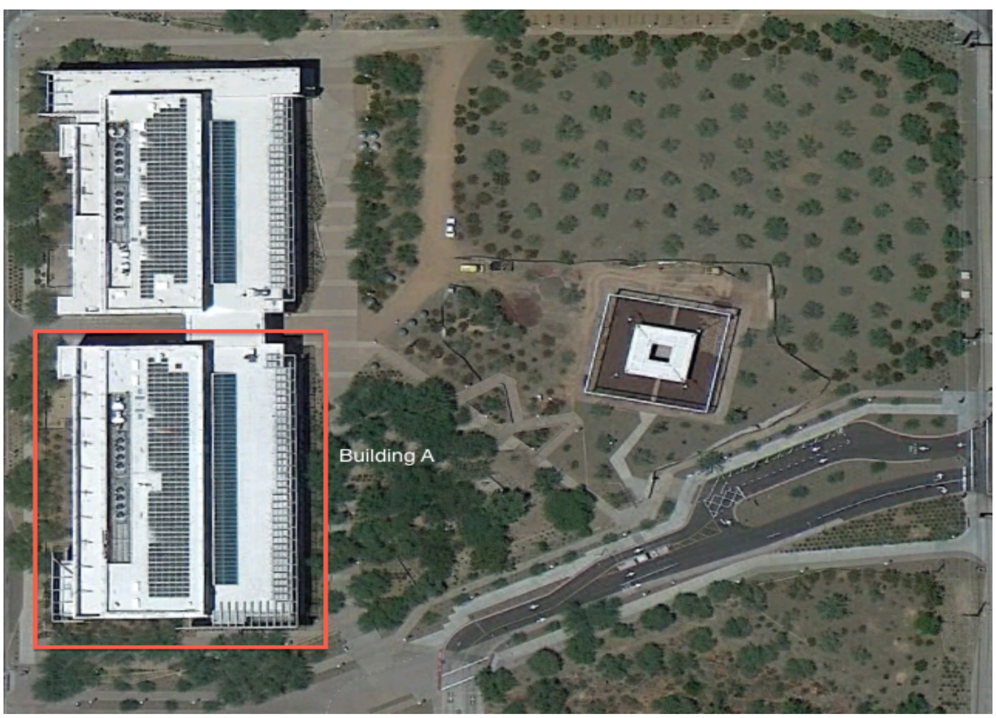

Image 2. ASSESSED BUILDING AND THE MAXIMIZED USE OF THE OPEN SPACE

(Source: Google Earth)

As far as the reduction of the UHI concerns, a reflective roof and a high albedo paving material along with vegetation that provides shading to the site were incorporated. In the light pollution credit, ASU amended its lighting rules and they were all distributed to the occupants.

5.2.2 WE Credit Category

Building A did perform well when tested on this classification. Once the prerequisites were fulfilled with the 20 percent reduction of water use in the whole calculated consumption for such a building, the calculation of points began.

Green areas are to obtain water from the air conditioning systems as they are used constantly, and produce around 19,000 liters of condensate water every day that is stored in a tank located in the basement and then released for irrigation (see Image 3). This, combined with the non-potable water collection and use in the irrigation system, complements water-conserving landscaping and overall effectiveness.

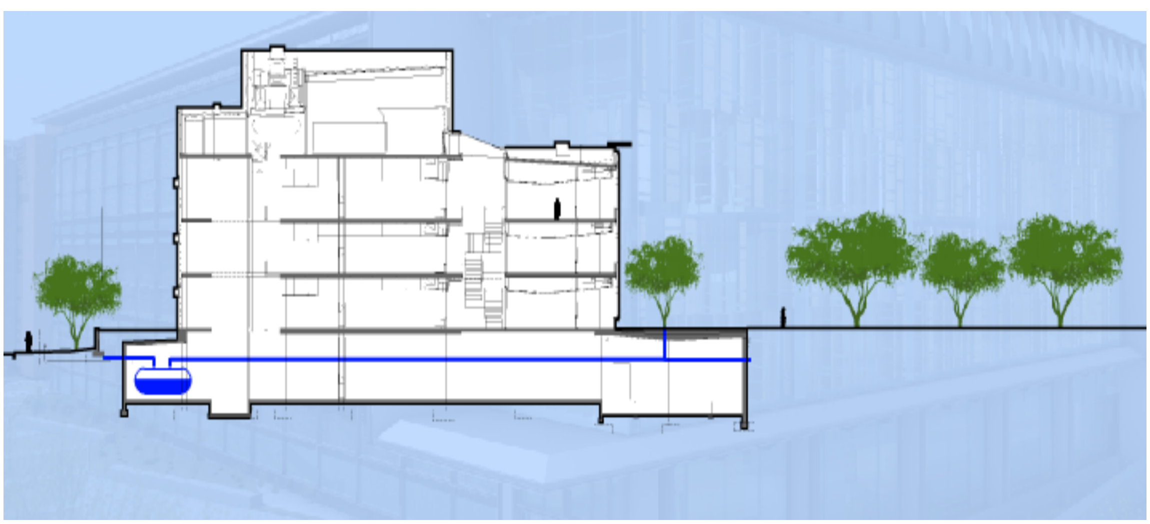

Image 3. Storage and distribution of irrigation water.

(Source: www.biodesing.asu.edu)

Additional low-flow plumbing accomplishes more reduction of potable water use yearly by almost 40 percent (Biodesign Institute, 2008).

The lack of water treatment was a weakness, preventing the collection of all possible points.

5.2.3 EA CREDIT CATEGORY

Even when high-quality equipment was incorporated into the building to ensure the adequate functioning of the prerequisites, and duty-bound commissioning activities (such as running a test for 48 hours on the mechanical systems) by an independent authority were enforced, the construction did not perform satisfactorily. Only a third of the total achievable points was acquired, which according to the engineers has been a difficult task.

Minimum energy performance was achieved by running an energy simulation and results were not as satisfactory in comparison with the provisions included in the ASHRAE Standard 90.1-2007, which provides energy efficiency minimum requirements.

Since the institute consists of two standing buildings at the present time, but separate ones, on-site renewable energy in Building A did not achieve any points as the 150 kW solar panel system they have installed is on Building B. In spite of this and according to the ASU website the following emissions are avoided:

- 220 Ton of CO_2
- 237 Kg of NO_x

The enhanced refrigerant management achieved one point by using an ozone-friendly gas. An outstanding feature is having a variable volume exhaust system that allows maintaining constant temperature to achieve energy saving and only varies the volume of air supplied into a room, which helps meet ventilation needs.

Another supplement was the transparent elements of the envelope, which are efficient, but also the daylighting techniques used were of support. The compliance path that the team chose for credit 1, which has the heaviest weight of all credits, was the achievement of energy savings and the on-site electricity production with the placement of photovoltaic panels, which also accounted for the green power credit, along with the purchase of green power from the American Wind Company of 3107 MWh distributed in two years.

5.2.4 MR Credit Category

The beginning of execution is the designation of areas for collection and storage or recyclable and materials waste. Landfill waste reduction was facilitated beforehand, achieving points because of the prerequisite in this category, which aims for the storage and collection of recyclables.

Four points out of fourteen were accomplished, but this was due to some of the credits not being accurately realistic to be part of a new building, such as the reuse of existing structures. This issue will be appointed when analyzing constrains of the LEED program for New Construction.

Construction waste management was achieved at its minimum by only recycling/salvaging 50% of the waste. This was due to the inability of sending waste to recycling facilities, because Arizona State does not have such capacity. Thus what could not be disposed of properly had to be sent to the landfill. However, according to their website, the Biodesign Institute project used about 15 percent of the overall material with recycled content, but this was only enough to get one of the two achievable points. The innovative characteristic is that the structure's concrete is composed of byproducts of coal burning power plants such as fly ash, clay and sand (cement.org, 2012). Use of this combustion byproduct was controversial due to its content of carcinogens and mutagenic elements, which are still in the air (Paradise, 2003); the DOE has actually pointed out such problematic issues. LEED needs to ensure that the amount of such substances is highly controlled or assess what has more priority, occupants' health or incorporation of recycle materials.

As an example, low maintenance and rapidly renewable rubber flooring was used and also incorporated 10 percent recycled content. The previous measurements are proportional to the area covered by the tiles.

The recycled content is around 15 percent of the total construction material used, and this number can be detailed as the Figure 9 shows:

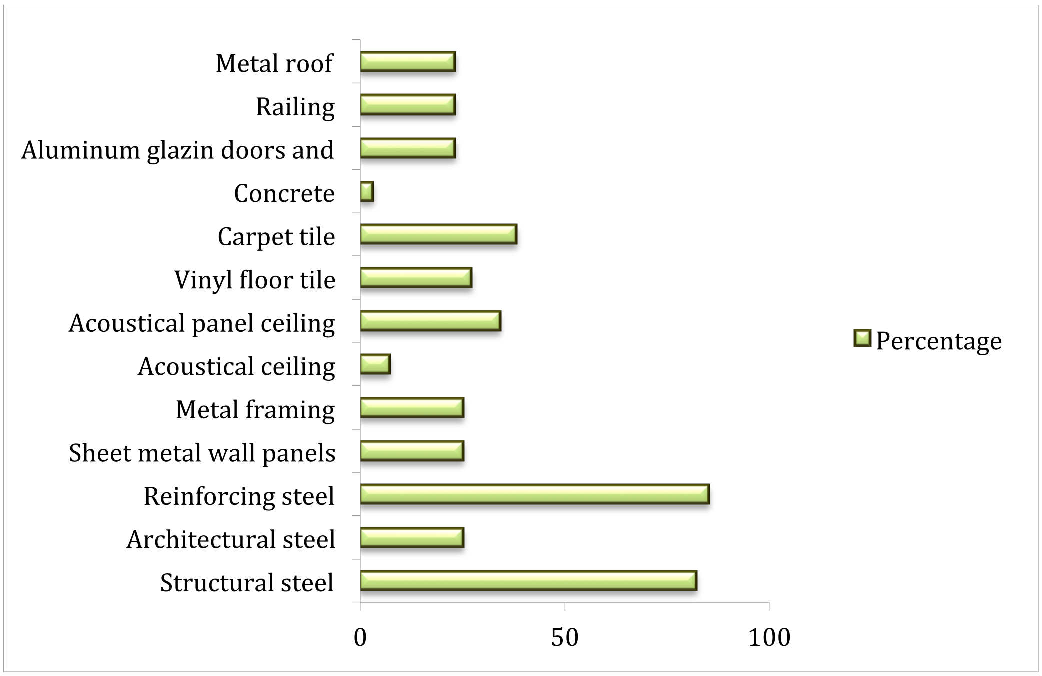

Figure 9. RECYCLED MATERIALS AND CONTENT USED IN THE BUILDING

(Source: www.biodesing.asu.edu)

Regarding the use of local materials, the team gained the two correspondent points to this credit by deciding on the Option 1 suggested in the LEED NC 2009 Guide, and 22 percent of the materials used were manufactured and extracted within 500 miles of the site. This makes a difference when they are implemented, but the rule should be stricter and the percentage of incorporation higher.

5.2.5 IEQ Credit Category

The variable air volume HVAC system is an essential part of the ventilation method. It is a complex process because the building is large and temperatures are adjusted differently in rooms, therefore ventilation is linked to this. Case 1 proposed was incorporated given the extreme hot and dry conditions of the site; natural ventilation is not a realistic approach.

The CO_2 monitoring system for mechanically ventilated spaces was applied and ventilation was also increased.

During construction, the team focused on containing the work area, modification of the HVAC operation, housekeeping was reinforced and the work hours were rescheduled. Low emitting products were incorporated, except in the category of paintings and coatings, as well as wood.

Before occupancy the building was flushed out so as to clean the indoor air before occupancy; this allowed the building to breath and be free of paint smells, furniture smells, etcetera.

Thermal comfort was not achieved, but again, this is such a personal and behavioral based standard. It is said that fifty percent of the buildings occupants should be satisfied and windows provided at certain distances from dwellers to control them (3 to 6 meters). If there is to be a large surface area on a floor this might be hard to do when some of the occupants are just not as close to the manual operability. This is defined by ASHRAE standards. Regardless, the credit of thermal comfort design was accomplished and similarities with the previous one seem confusing, as the ASHRAE 55-2004 standard is used again.

Even when the design incorporated an atrium to provide natural light into the building, and controllable north and east louvers were also implemented, overheating of the envelope was quite the challenge to overcome. The illumination features can be seen in the orangeframed areas in Image 4. The goal of illuminating 75 percent of the occupied spaces was not possible. Nonetheless, sun-angle was adequate.

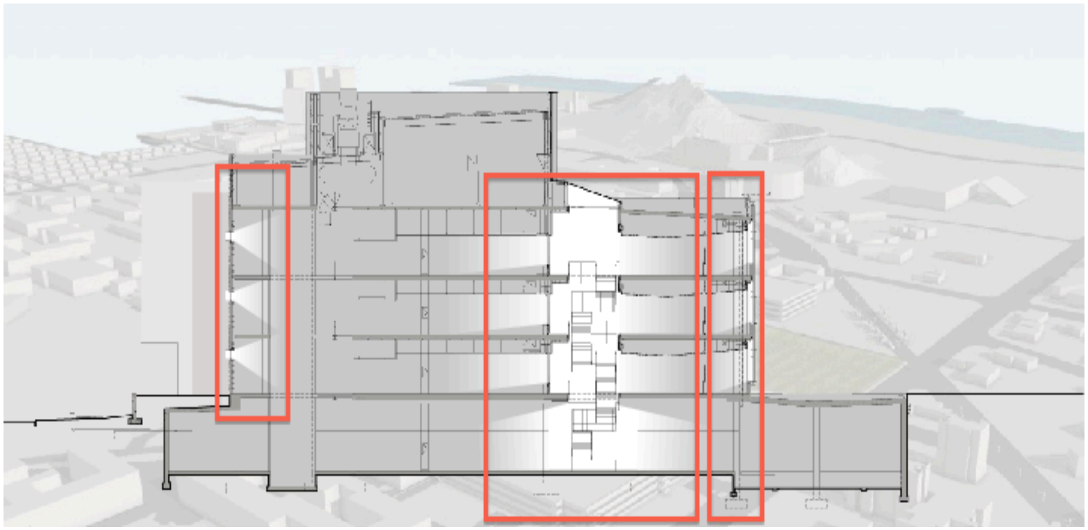

Image 4. NATURAL LIGHTING FEATURES

(Source: *www.biodesing.asu.edu)*

On the other hand, the credit for views was well performed. The team project argues that 90 percent of the occupied spaced in the institute has visual connections with the exterior environment, and therefore wellbeing is increased (see Image 5)

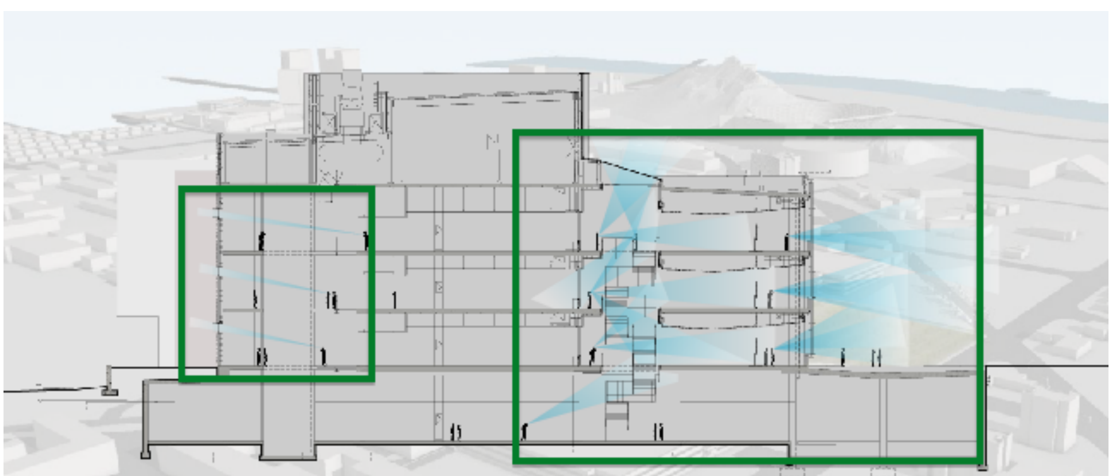

Image 5. AVAILABLE VIEWS TO THE EXTERIOR OF THE BUILDING

(Source: www.biodesing.asu.edu)

5.2.6 ID Credit

All credits in this category were obtained; most importantly, having in the team an Accredited Professional familiar with the process and methods was key.

The last allocation of credits corresponds to Regional Priority, but since the building was assessed with previous version before LEED 2009, this was not taken into consideration yet.

5.3 WHAT COULD HAVE BEEN DONE BETTER

According to the director of University Sustainability Practices, getting each student and faculty staff familiar with the particularities of the building has to be done in a more engaged way, but also giving them this information to take and put it in practice in their homes would have a much greater impact.

Raising energy conservation awareness among the building's occupants is an ongoing process and in constant movement because students come and go, thus these could even achieve an extra 10 percent of energy savings (Bentzin, 2010).

5.6 FLAWS FOUND IN LEED NC 2009

a) In the manual for LEED 2009 for New Construction, it is said that the system's scope does not involve significant design of construction activities, but that it focuses more on the operation and maintenance activities; however, in the SS credit 26 points are achievable, comprising around 14 percent of the total achievable points. This a large portion in which easily five points can be lost in credit 1.1 regarding building reuse - maintaining existing walls and roofs, and in credit 1.2 in building reuse - maintaining existing interior non-structural elements, if the application is done to an entire building. This is more focused on major renovations, but if the building is completely new LEED needs to be more flexible at assessing these points.

b) Commissioning in two of the Credit Categories is a prerequisite, and subsequently Enforced Commissioning is mentioned again. In the research done, it has been found that this is one of the biggest challenges because it is not easy to have a team running commissioning to one building once a year that dedicates all of the member's activities to it. A suggestion would be to have the entire commissioning section all together and make it a whole, single, strongly enforced prerequisite; therefore a team could engage in other projects.

c) LEED emphasizes strongly ASHRAE standards, especially ASHARE 90.1. While this provides a fairly easy way to choose materials or devices, it does not truly measure energy savings and cannot predict energy use. Whereas it is understandable that this is a more accessible path, it should be stricter so as to have the professionals aware of real numbers and units of energy saved in certain project. Though occupants on the other hand could have a hard time understanding such figures, then here is where education and creativity to explain should be present.

d) The LEED NC checklist that contains what is required to achieve points in each credit does not proportion detailed information about energy efficiency. It is not a rational instrument, and this limits the team's approach to the functioning of the building and its mechanisms. Therefore the checklist does not represent accurate success about a building's performance.

e) The incorporation of ASHRAE or any other standard does not help measure energy savings, which overall is the entire purpose of pursuing green certification. It is more directed to encourage the use of certain products.

f) Once the certification is done there is no follow up.

g) The software programs are complicated to use, and if one is to predict energy performance training on the tool in necessary.

6. LEED VS. CASBEE, A THEORETICAL COMPARISON

Due to the lack of specification about the materials used, equipment or measures taken, it is not realistic to evaluate the Biodesign Institute with CASBEE and therefore, have an accurate result about the labeling.

Regardless, when studying this case at a first glance, it was observed that when assessing a building with LEED the certification is given based on predictions done at the pre-design phase and after that there is no further measurement of the real consumption of energy and thus the savings. CASBEE assesses the different stages of a building's life, and when the evaluation is done on a New Construction, a subsequent one must be done after three years with the tool CASBEE for Existing Buildings. Evidently this make more sense, as applicants are always considering going on further in technology, but also in methodology and behavior of the occupant that can contribute to a better performance every time.

CASBEE offers a Technical Manual for each if its assessment tools. In this manual, processes of evaluation of the various Q and L level are described. Table 4 depicts each of them and how they could be related to any of the LEED checklist items in the study case. Note that empty cells represent no extra methodology in the LEED program.

Table 4. ENVIRONMENTAL QUALITY EVALUATION ITEMS

Q1. Quality of the Building (Analogous to the LEED IAQ Credit Category)				
			LEED inclusion	**Potential in LEED**
	1. Sound Environment	Noise, sound insulation and sound absorption.	PARTIAL, could or could not be included in the design.	YES. Insulation for energy conservation could include and mandate it but also as an occupant's requirement in working conditions

				and comfort at the working place.
	2.Thermal Comfort	Room temperature control, humidity control and type of air conditioning system.	YES	It could be addressed with more allocation of points, given that wellbeing is dependent of equipment such as the HVAC systems. In the case of humidity, this should be included or not depending on the location of the site.
	3. Lighting & Illumination	Daylight, antiglare measures, luminance levels and lighting controllability.	YES	As an example, in the study case the items of this category were well treated since glare in the desert can be extremely challenging, as well as a good design to control direct lighting entering through the windows. In general the category is well adopted.
	4. Air Quality	Source control, ventilation, and	YES, included in RM and IAQ	LEED addresses the content in a

		operation plan.	LEED categories.	logical way.
Q2. Quality of Service (Analogous to LEED SS and all its commissioning areas along with IAQ)				
			LEED inclusion	**Potential in LEED**
	1. Service Ability	Functionality and usability, amenity, maintenance management.	PARTIAL	LEED is good at addressing community connectivity, but enforcement of commissioning represents an area of great potential.
	2. Durability and Reliability	Earthquake resistance, service life of components, reliability.	PARTIAL	LEED does not consider natural disasters, although some states experience floods, tornados, etc. Durability of materials used is encouraged and it is part of their life cycle analysis.
	3. Flexibility and Adaptability	Spatial margin, floor load margin, system renewability.	NO	LEED certified buildings are not considered to have alternative uses. Could be included, but when it comes to cases such as that of the Biodesign Institute, it is unlikely that a

				change in the line of business will happen.
Q3. Outdoor environment on site (Analogous to LEED SS Credit Category)				
			LEED inclusion	**Potential in LEED**
	1. Preservation and Creation of Biotope	Wildlife preservation or allowance to surround the building with indigenous plants.	YES	
	2. Townscape & Landscape	Urban context and scenery according to Japanese urban Context Guidelines	NO	Building codes in some states can enforce the prohibited alteration of the scenery in particular locations.
	3. Local Characteristics & Outdoor Amenity	Attention to local character and improvement of comfort and thermal environment on site	PARTIAL	Cultural heritage is not possible to address in US because of diversity equality. But the alleviation of HIE is well addressed in LEED and a priority in the case study, as the local climatic conditions are extreme.

Table 5 below, corresponds to the Load Reduction.

Table 5. LOAD REDUCTION EVALUATION

LR1. Energy (Analogous to LEED EA Credit Category)				
			LEED inclusion	**Potential in LEED**
	1. Building Thermal Load	Standardization on the Perimeter Annual Load stated in the Energy Conservation Law of Japan in MJ/year/m^2 as the relations between thermal flow and floor area indoors.	UNKNOWN, information about the measurements of loads is limited, as this is carried out with separate software.	
	2. Natural Energy Utilization	Natural lighting and use of renewable energy	YES	
	3. Efficiency in Building Service Systems	Reduction rate of primary energy consumption	YES	ASHRAE standards for efficiency of appliances and equipment.
	4. Efficient Operation	Monitoring and management system.	YES	It needs enforcement in the design phase, normally overlooked.
LR2. Resources and materials (Analogous to LEED MR and EA Credit Category)				
			LEED inclusion	**Potential in LEED**
	1. Water Resources	Water saving, rainwater and grey water.	YES	
	2. Reducing Usage of Non-Recyclable Resources	Reducing usage of materials, continuing use of existing structural frames, use of recycled materials as structural frame materials, use of recycled materials as non-structural materials, timber from sustainable forestry, efforts to enhance reusability of components and	YES	The category addressing materials should include certified wood and become one allocation of credits. CASBEE puts them together.

		materials.		
	3. Avoid the Use of Materials with Pollutant Content	Use of materials without harmful substances and elimination of CFCs and halons.	YES	Specifically, halons are banned in the refrigerant management.
LR3. Off-site environment				
			LEED inclusion	**Potential in LEED**
	1. Consideration of Global Warming	CO_2 reduction initiatives based on $LCCO_2$ indicator	PARTIAL	It is indicated that it should be monitored, and efforts to reduce energy consumption are highly important. Regardless LEED does not separate this category as CASBEE does. It could be added so as to provide more information about their emissions diminishment and to raise awareness and education to occupants.
	2. Consideration of Local Environment	Air pollution, heat island effect, load and local infrastructure	YES	
	3. Consideration of Surrounding Environment	Noise, vibration and odor, wind/sand damage and daylight obstruction, light pollution	PARTIALLY	Noise, vibrations and odor are not considered. If LEED is to evaluate factories where industrial processes are taking place, it should be included, but in the case of the institute, too, because chemical substances are managed. Odors then are only treated indoors.

Other considerations are:

1) In LEED, only building codes back up the prerequisites and other mandatory regulations; therefore, the allocation of credits is based on standards written by different organizations whose fundamental activity it is. CASBEE instead bases all its assessments on Japanese Law and the standards contained in them, so there is more law enforcement.

2) On the other hand CASBEE does not observe the encouragement of alternative transportation uses, but this could be done because this is a cultural trend, and it may be taken as granted since this is an intensively used way of transportation as a result of the overpopulated surface area which is Japan. It is a completely different approach, as in the United States the majority of the population depends on their cars for most of their daily activities.

CONCLUSIONS

Because of the great interest that green buildings have gained in the last twenty years, their evaluation and rating of how environmentally friendly they are have led to the creation of tools dedicated to their assessment. The main purpose of conducting this investigation was to analyze two of those main building rating systems.

This analysis, theoretically conducted on two tools developed in different areas of the world, helped identify their strengths and weaknesses and make suggestions about how they could help improve each other. The project was achieved through the revision of different documents, publications, books and one study case of a Gold Certified building in the Leadership in Energy and Environmental Design system.

LEED, established in the United States, is not a complex tool given that the USGBC provides those that are pursuing certification with checklists of what a project should comply with in order to achieve points. It is rather easy to understand, but it does not seem to be very demanding and strict in terms of achieving energy efficiency, which at the end of the road should be the main goal of a green building.

On the other hand, the Japanese Comprehensive Assessment System for Built Environmental Efficiency (CASBEE) measures energy efficiency by analyzing the environmental quality inside and outside the building and their correlation with the loads of energy in it, in terms of energy, materials and the off-site environment. This relationship possibly makes the system more complex but, because of that complexity, it invites occupants, engineers, designers and architects to get more involved in understanding how to build the greenest building with innovative ideas, instead of only following a checklist and obtaining the suggested products that fall into certain standards.

A second downfall is that LEED NC does not perform a follow-up evaluation once certification has been achieved. Therefore, there is no mandatory revision of compliance or measurements of actual energy savings because the tool bases the assessment on simulations. CASBEE NC, instead, mandates a follow up in the historic energy measurements collected after three years of the first certification and then, if the scoring is appropriate, the status and labeling are given on terms of CASBEE for Existing Buildings. This makes more sense, and the project team is more committed to keeping a high quality in the building, so as to keep their labeling or to improve it.

An outstanding feature of CASBEE is how it was designed around the environmental problems and geographic features of Japan. By doing so, building are made around those specific necessities and adapted.

Hence, it was concluded that even when the LEED system is still on its way to making more improvements on how it evaluates buildings, it needs to do it fast, as the great potential that CASBEE has to be adapted in different areas of the world – given that regionalization pinpoints local aspects, either good or bad – could lead to it being more widely used in the United States. So, LEED could take as an example this and many other things from the CASBEE tool and incorporate them into itself the way it evaluates projects. A fault, and what could potentially bring LEED down, is how greatly it based on standards, limiting creativity and innovation.

Ultimately, energy savings should always be the main focus, without compromising the occupant's health and resources. The instruments need to keep improving, as the problems regarding the environment and its quality change or become more alarming.

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APPENDIX 1.

Sustainable Sites		**Total achieved: 22 points**
Prerequisite 1	Construction Activity Pollution Prevention Required	Required
Credit 1	Site Selection	1
Credit 2	Development Density and Community Connectivity	5
Credit 3	Brownfield Redevelopment	X
Credit 4.1	Alternative Transportation—Public Transportation Access	6
Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	X
Credit 4.4	Alternative Transportation—Parking Capacity	2
Credit 5.1	Site Development—Protect or Restore Habitat	1
Credit 5.2	Site Development—Maximize Open Space	1
Credit 6.1	Stormwater Design—Quantity Control	1
Credit 6.2	Stormwater Design—Quality Control	1
Credit 7.1	Credit 7.1 Heat Island Effect—Nonroof	1
Credit 7.2	Credit 7.2 Heat Island Effect—Roof	1
Credit 8	Credit 8 Light Pollution Reduction	1
Water Efficiency		**Total achieved:**

		8
Prerequisite 1	Water Use Reduction	Required
Credit 1	Water Efficient Landscaping 2-4	4
Credit 2	Innovative Wastewater Technologies	X
Credit 3	Water Use Reduction	4
Energy and Atmosphere		**Total achieved: 12 points**
Prerequisite 1	Fundamental Commissioning of Building Energy Systems	Required
Prerequisite 2	Minimum Energy Performance	Required
Prerequisite 3	Fundamental Refrigerant Management	Required
Credit 1	Optimize Energy Performance	8
Credit 2	On-site Renewable Energy	X
Credit 3	Enhanced Commissioning	X
Credit 4	Enhanced Refrigerant Management	2
Credit 5	Measurement and Verification	X
Credit 6	Green Power	2
Materials and Resources		**Total achieved: 5 points**
Prerequisite 1	Storage and Collection of Recyclables	Required
Credit 1.1	Building Reuse—Maintain Existing Walls, Floors and Roof	X
Credit 1.2	Building Reuse—Maintain Existing Interior Nonstructural	X

	Elements	
Credit 2	Construction Waste Management	1
Credit 3	Materials Reuse	X
Credit 4	Recycled Content	1
Credit 5	Regional Materials	2
Credit 6	Rapidly Renewable Materials	1
Credit 7	Certified Wood	X
Indoor Environmental Air Quality		**Total achieved: 11 points**
Prerequisite 1	Minimum Indoor Air Quality Performance Required	Required
Prerequisite 2	Environmental Tobacco Smoke (ETS) Control Required	Required
Credit 1	Outdoor Air Delivery Monitoring	1
Credit 2	Increased Ventilation	2
Credit 3.1	Construction Indoor Air Quality Management Plan—During Construction	1
Credit 3.2	Construction Indoor Air Quality Management Plan—Before Occupancy	X
Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
Credit 4.2	Low-Emitting Materials—Paints and Coatings	X
Credit 4.3	Low-Emitting Materials—Flooring Systems	1
Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	X
Credit 5	Indoor Chemical and Pollutant Source Control	1

Credit 6.1	Controllability of Systems—Lighting	1
Credit 6.2	Controllability of Systems—Thermal Comfort	X
Credit 7.1	Thermal Comfort—Design	1
Credit 7.2	Thermal Comfort—Verification	1
Credit 8.1	Daylight and Views—Daylight	X
Credit 8.2	Daylight and Views—Views	1
Innovation in Design		Total achieved: 6 points
Credit 1	Innovation in Design	5
Credit 2	LEED Accredited Professional	1

APPENDIX 2

LEED 2009 FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS PROJECT CHECKLIST

Sustainable Sites			**26 Possible Points**
☑	Prerequisite 1	Construction Activity Pollution Prevention	Required
■	Credit 1	Site Selection	1
■	Credit 2	Development Density and Community Connectivity	5
☐	Credit 3	Brownfield Redevelopment	1
■	Credit 4.1	Alternative Transportation—Public Transportation Access	6
■	Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
☐	Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehicles	3
■	Credit 4.4	Alternative Transportation—Parking Capacity	2
■	Credit 5.1	Site Development—Protect or Restore Habitat	1
■	Credit 5.2	Site Development—Maximize Open Space	1
■	Credit 6.1	Stormwater Design—Quantity Control	1
■	Credit 6.2	Stormwater Design—Quality Control	1
■	Credit 7.1	Heat Island Effect—Nonroof	1
■	Credit 7.2	Heat Island Effect—Roof	1
■	Credit 8	Light Pollution Reduction	1
Water Efficiency			**10 Possible Points**
☑	Prerequisite 1	Water Use Reduction	Required
■	Credit 1	Water Efficient Landscaping	2-4
☐	Credit 2	Innovative Wastewater Technologies	2
■	Credit 3	Water Use Reduction	2-4
Energy and Atmosphere			**35 Possible Points**
☑	Prerequisite 1	Fundamental Commissioning of Building Energy Systems	Required
☑	Prerequisite 2	Minimum Energy Performance	Required
☑	Prerequisite 3	Fundamental Refrigerant Management	Required
■	Credit 1	Optimize Energy Performance	1–19
☐	Credit 2	On-site Renewable Energy	1–7
☐	Credit 3	Enhanced Commissioning	2
■	Credit 4	Enhanced Refrigerant Management	2
☐	Credit 5	Measurement and Verification	3
■	Credit 6	Green Power	2
Materials and Resources			**14 Possible Points**
☑	Prerequisite 1	Storage and Collection of Recyclables	Required
☐	Credit 1.1	Building Reuse—Maintain Existing Walls, Floors and Roof	1-3
☐	Credit 1.2	Building Reuse—Maintain Existing Interior Nonstructural Elements	1
☐	Credit 2	Construction Waste Management	1-2
☐	Credit 3	Materials Reuse	1-2
■	Credit 4	Recycled Content	1-2

LEED 2009 FOR NEW CONSTRUCTION AND MAJOR RENOVATIONS RATING SYSTEM

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■	Credit 5	Regional Materials	1-2
■	Credit 6	Rapidly Renewable Materials	1
☐	Credit 7	Certified Wood	1

Indoor Environmental Quality **15 Possible Points**

☑	Prerequisite 1	Minimum Indoor Air Quality Performance	Required
☑	Prerequisite 2	Environmental Tobacco Smoke (ETS) Control	Required
■	Credit 1	Outdoor Air Delivery Monitoring	1
■	Credit 2	Increased Ventilation	1
■	Credit 3.1	Construction Indoor Air Quality Management Plan—During Construction	1
☐	Credit 3.2	Construction Indoor Air Quality Management Plan—Before Occupancy	1
■	Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1
☐	Credit 4.2	Low-Emitting Materials—Paints and Coatings	1
■	Credit 4.3	Low-Emitting Materials—Flooring Systems	1
☐	Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1
■	Credit 5	Indoor Chemical and Pollutant Source Control	1
■	Credit 6.1	Controllability of Systems—Lighting	1
☐	Credit 6.2	Controllability of Systems—Thermal Comfort	1
■	Credit 7.1	Thermal Comfort—Design	1
■	Credit 7.2	Thermal Comfort—Verification	1
☐	Credit 8.1	Daylight and Views—Daylight	1
■	Credit 8.2	Daylight and Views—Views	1

Innovation in Design **6 Possible Points**

■	Credit 1	Innovation in Design	1-5
■	Credit 2	LEED Accredited Professional	1

Regional Priority **4 Possible Points**

☐	Credit 1	Regional Priority	1-4

LEED 2009 for New Construction and Major Renovations

100 base points; 6 possible Innovation in Design and 4 Regional Priority points

Certified	40–49 points
Silver	50–59 points
Gold	60–79 points
Platinum	80 points and above