Developing a green building rating system for Egypt

Vivian Adel Younan
The American University in Cairo AUC

The American University in Cairo
School of Sciences and Engineering

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BY

Vivian Adel Younan

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science in Construction Engineering

Under the supervision of:

Dr. Salah El Haggar
Chairman of Mechanical Engineering Department
American University in Cairo

Dr. Khaled Nassar
Associate Professor of Construction and Architectural Engineering
American University in Cairo

Spring 2011

ACKNOWLEDGMENTS

First and for most, I have to thank God for this great chance I have right now. I thank God for providing me with the opportunity to meet such helpful and wonderful people those who helped me from the start when I started to plan to join the American University in Cairo and even long before that.

I would like to express my profound gratitude and appreciation to both of my advisors Dr. Salah El Haggar and Dr. Khaled Nassar. You were both very helpful, extremely knowledgeable and most importantly a great aid with your kind patience with me till I fulfilled this work. Dr. Salah, the kind guidance you gave me during my ups as well as my downs was one of the reasons I was able to be here today. Dr. Khaled, your continuous help directed me to the correct path. I couldn’t have done it without you both.

I also thank all professors here in the construction and architectural department at the American University in Cairo who provided me with their experience, valuable time and knowledge.

I would like to thank Dr. Emad Imam and Dr. Ahmed Sherif for believing in me from the start and giving me the chance to be here in the American University in Cairo.

I would like also to thank the professors I worked with as a teaching assistant for giving me that chance where I learnt a lot. I would specially like to express my appreciation to Dr. Maged Morcos for his kind and great support throughout all the time I had the pleasure of working as his teaching assistant.

Finally, I can’t forget the help, continuous support and paramount sacrifices of my family, my fiancé and friends not only to finish my master’s degree, but also be a better person on all levels. They are all my true treasure. I thank God for them.

ABSTRACT

DEVELOPING A GREEN BUILDING RATING SYSTEM FOR EGYPT

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Buildings have a large impact on the environment; Water pollution, Energy consumption, Waste generation and CO_2 emission are some of the negative effects that a building can have on the environment. The act of reducing the negative effects of a building on environment is called “Going Green”. Leaving the environment for future generations’ use -or in other words have no impact on the environment- means “being Sustainable” The success in this process depends on many criteria; and the only way to insure its success is to have a way to assess them.

There are many tools for environmental assessment; from them is rating systems. There are many available rating systems on the market, yet from the comparative analysis performed in this thesis, one can notice that each rating system is accommodated to suite the environment for which it was designed for. For example, LEED is mainly concerned with energy use and gives lower importance to water while BREEAM Gulf does exactly the opposite thing. This is why a new special rating system that suites and matches the needs of the construction industry and environment in Egypt was needed to be developed.

To do that, s survey of the methodologies used to develop green building rating systems in several countries –Greece, Lebanon and Jordan- were explored in order to use

their methodologies as a guide. From that it was concluded that first, a comprehensive list of categories and their sub categories that affect green buildings needed to be developed. In order to develop it, a comparative analysis was done for four rating systems-GREEN GLOBES, LEED V3 NC, BREEAM Gulf and ESTIDAMA. They were chosen to be two regional rating systems and two international rating systems. From that comparison, both the weights of the categories weights for the four rating systems compared as well as the comprehensive list of sub categories was developed. From that list, a questionnaire was formed, Then from the weights calculated using an analytic hierarchy process, the resulting weights were further compared with the original four rating system for refining.

The participants gave the highest weight to water and energy use with a slightly higher weight to water use of 20% and 19% to energy use. Also, when the resulting weights were compared to the weights given by the rating systems compared, Pollution got a relatively high weight of 16% with another unexpected result of the relatively low weight for renewable energy sources of 15%. The remaining five main categories materials, indoor environmental quality, livable outdoors and transportation, site ecology and other sustainable systems and processes got nearly equal weights ranging from 8 to 10%. The participants were familiar with green buildings and LEED. They were also from different fields, companies and areas of interest. Their answers were consistent, as shows in the AHP consistency index. So the resulting weights are reliable.

The main outcomes of this thesis are a list of main categories and sub categories with the weights for the main categories, the energy use sub categories and water use sub categories.

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Rating systems

BEAM	Building Environmental Assessment Method
BCA Green Mark	Singapore Building and Construction Authority Green Mark
BREEAM	Building Research Establishments' Environmental Assessment Method
CASBEE	Comprehensive Assessment System for Building Environmental Efficiency
CHPS	Collaborative for High Performance Schools
GBAS	Green Building Assessment System
GG	GREEN GLOBES
GGHC	Green Guide for Health Care
GRIHA	Green Rating for Integrated Habitat Assessment
GSBC	German Sustainable Building Certification
HQE	Haute Qualite' Environnementale "high Quality Environmental Standard"
LEED	Leadership in Energy and Environmental Design
NABERS	National Australian Built Environment Rating System
NGBS	National Green Building Standard
SBTOOL	Sustainable Building Tool

Miscellaneous items

ANSI	American National Standards Institute
ASHE	the American Society for Healthcare Engineering
ASSOHQE	Association pour la Haute Qualite' Environnemnentale
A/Es	Architects/Engineers and
BEC	the Business Environment Council
BIQ	building intelligence quotient
BMVBS	Federal Ministry of Transport, Building and Urban Development
BRE	Building Research Establishment
CABA	the continental Association for Building Automation
CBA	Cost-benefit analysis
CERA	Cumulative energy requirements analysis
CHBA	the Canadian Home Builders' association
DGNB	the German Sustainable Building Council
ECD	Energy and Environment Canada
EOL	End-of-Life management
EPE	Environmental performance evaluation
ERA	Environmental risk assessment

GBC	the Green Building Challenge
GBCA	Green Building Council Australia
GBI	Green Building Initiative
GOBAS	China’s Green Olympic Building Assessment System
IDP	Integrated Development Process
IOA	Environmental input/output analysis
JaGBC	the Japan Green-Build Council
JSBC	the Japan Sustainable Building Consortium
LCA	life-cycle assessment
LCC	Checklists for eco-design, life-cycle costing
LCM	Life cycle management
LCT	Life cycle thinking concept
LGBC	Lebanon Green Building Council
MFA	Material flow accounting
MIPS	Material intensity per service unit
MoST	the Ministry of Science and Technology in China
NAHB	National Association of home builders
NRCan	Natural Resources Canada

NSW	New South Wales Government
OEE	the Office of Energy Efficiency
O/Ds	Owners/Developers
TCA	Total cost accounting
TERI	the Energy and Resources Institute
TQEM	Total quality environmental management
UPC	The Urban Planning Council in Abu Dhabi
USGBC	the US Green Building Council

CHAPTER 1

INTRODUCTION

1.1 IMPORTANCE OF GOING "GREEN"

Buildings have a huge impact on the environment as they use materials that are extracted from nature, and then transported for long distances consuming the available roads (Mezher, 2006). Later during construction, workers work in a very polluted and noisy environment affecting neighboring citizens. Building users use up water and energy producing waste water, solid waste, Carbon and Radon. In the end of the building lifetime it is demolished generating demolition waste.

Some of the current environmental issues in Egypt are (CIA):
"agricultural land being lost to urbanization and windblown sands; increasing soil salination below Aswan High Dam; desertification; oil pollution threatening coral reefs, beaches, and marine habitats; other water pollution from agricultural pesticides, raw sewage, and industrial effluents; limited natural freshwater resources away from the Nile, which is the only perennial water source; rapid growth in population overstraining the Nile and natural resources"

Nearly 40% of the energy usage in Egypt is residential which exceeds the 35% total consumption of energy by industry (Egyptian Electricity Holding Company, 2009). Two factors caused the substantial increase in residential electricity loads compared to that of industry during year 2008/2009. Those factors are the international financial crises that affected industrial demand in

addition to the extensive use of domestic appliances especially air conditioning in houses. This is shown in figure 1 and figure 2.

Each stage of the construction process has a different effect on the environment. This is shown in Table 1 and figure 3. It can be observed from table 1 that one of the most dominant impacts of construction stages on the environment is energy consumption as well as CO_2 emission. In figure 3, energy consumption levels in different construction stages are compared to the general environmental impact of these stages.

As observed from figure 3, it can be noticed that the most environmental impact from a construction is at the life cycle stage. The energy consumption is lower than the environmental impact in almost all the stages as the former is only part of the later. The energy consumption is noticed to be slightly higher during the transportation and distribution stage due to the use of petrol operated vehicles.

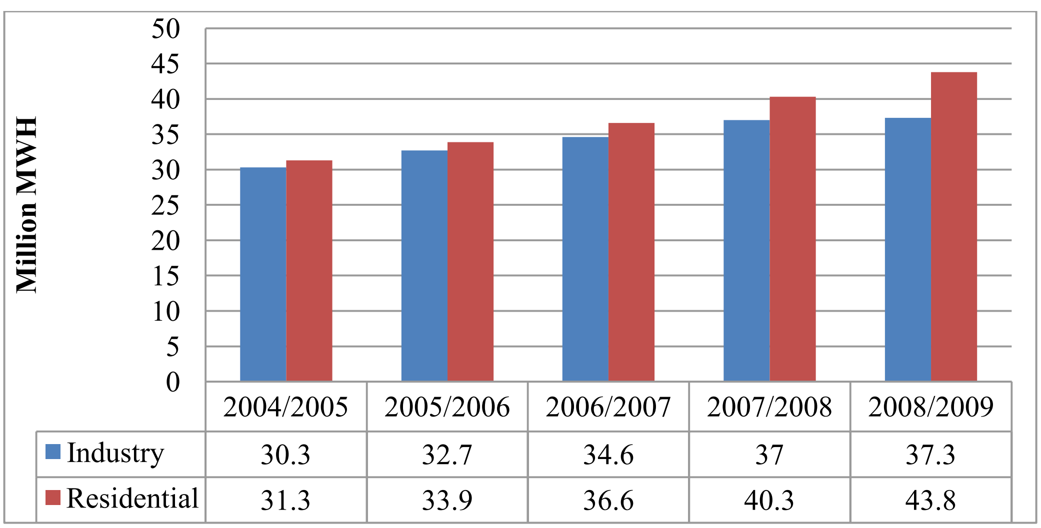


Figure 1 – Residential electricity loads in comparison with that of industry (Egyptian Electricity Holding Company, 2009)

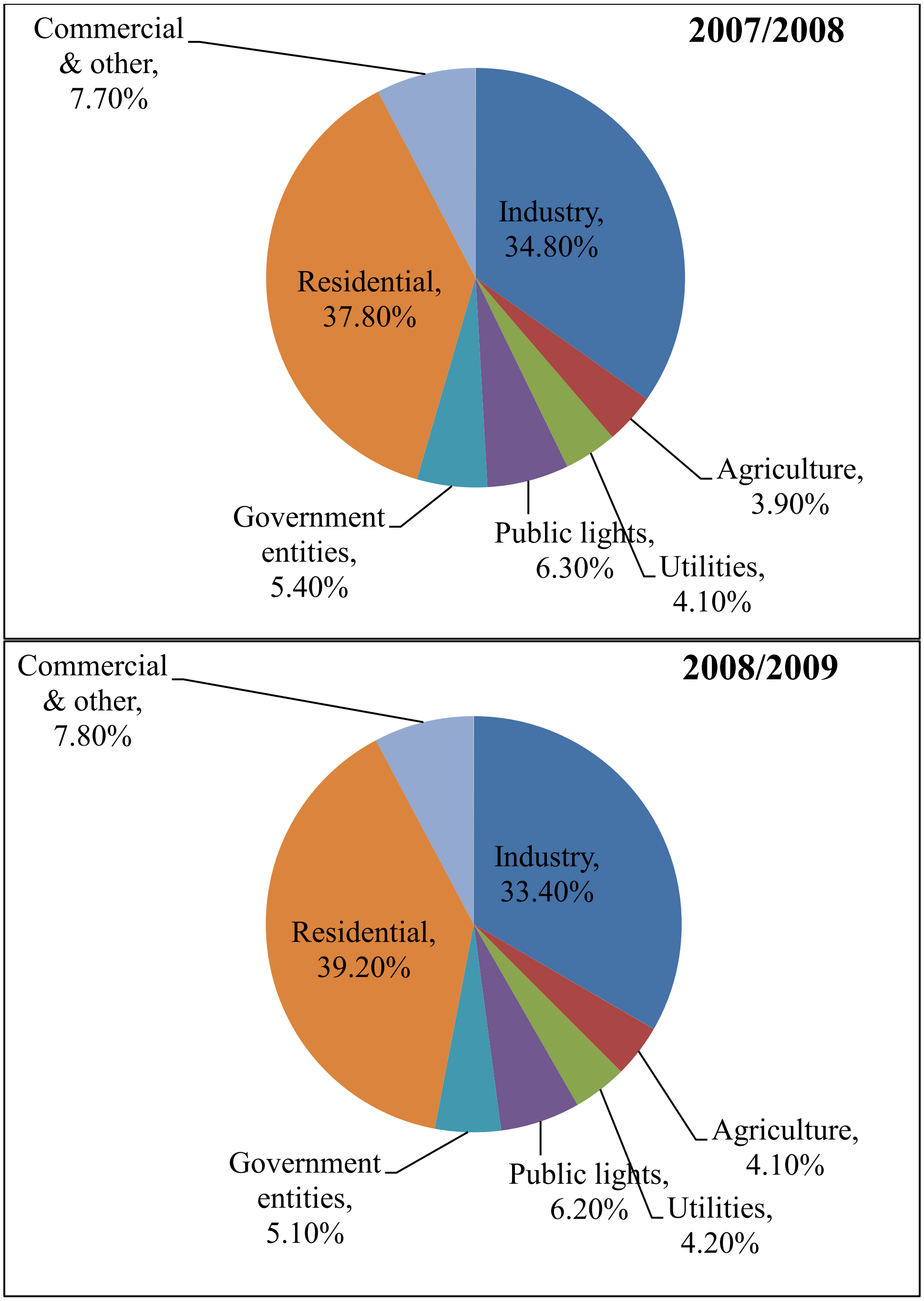


Figure 2 - Energy sold by Purpose of usage in 2007/2008 versus 2008/2009 (Egyptian Electricity Holding Company, 2009)

Table 1 - Environmental impacts of construction process stages (Attmann, 2010)

Activity	**Environmental impacts**
Mining/Drilling/Extracting	• Deforestation • Destruction of plant and animal habitat • Existing settlements • Land erosion • Water pollution
Manufacturing/Assembly	• Energy consumption (impacts of producing energy) • Waste generation
Transportation/Distribution	• Energy consumption • CO_2 emission • Resource use (packaging)
Building	• CO_2 emission • Pollution and radiation from the materials and technologies (exposed to chemical and climatic activities) • Pressure and damage
Maintenance/Life cycle	• Energy consumption • CO_2 emission • Resource use and replacement • Wear and tear

Activity	Environmental impacts
	• Chemical contamination (material loss-from roofs, pipes) • Water pollution
Demolition	• Chemical contamination • Toxicity • Environmental poisons
Recycle/waste	• Landfill decomposition • Groundwater contamination • Methane gas production

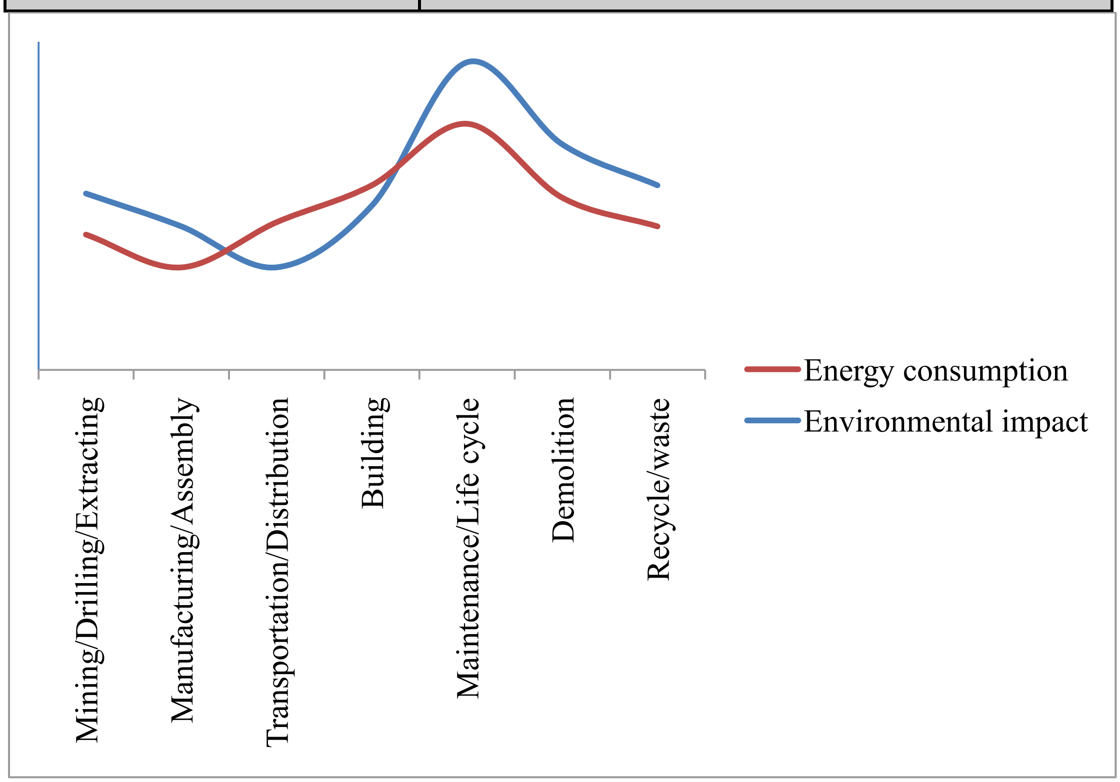


Figure 3 - The environmental impact and energy consumption of green construction (Attmann, 2010)

1.2 COST OF GOING "GREEN"

In table 2, the goals and benefits of green construction is discussed from the planet's (environmental), profit (economic), and social point of view with the possible constrains faced by each party.

One constrain that faces green construction, is the common perception that green buildings cost more. This is not true as shown in figure 4 (Langdon, 2007). It demonstrates a study on the prices of certified versus non certified library buildings in the USA – being certified means a building is green while non-certified doesn't necessarily mean the opposite but getting a certification for a green building costs minimally extra money in exchange of the label.

In Table 3, the main influence of cost for green building projects in the case of LEED certification is shown with their corresponding possible cost increases.

Table 2 – Triple bottom line goals for a green building (Yudelson, 2009)

Planet/Environmental	Profit/Economic	People/Social
Goals to strive for		
Reduce energy consumption 50%	Reduce energy costs 50%	Be a good corporate citizen
Reduce greenhouse gas emissions 50%	Reduce water costs 50%	Provide a healthy work environment
Reduce water usage 50%	Reduce maintenance costs	Reduce greenhouse gas emissions
Reduce waste produced during construction and during operations	Increase productivity	Maximize utilization of resources
Protect biodiversity	Reduce risk of sick building-related issues	Reduce overall carbon footprint
Constraints		
Site is already selected	Owners payback targets are <10 years	Limited experience internal to owners' team

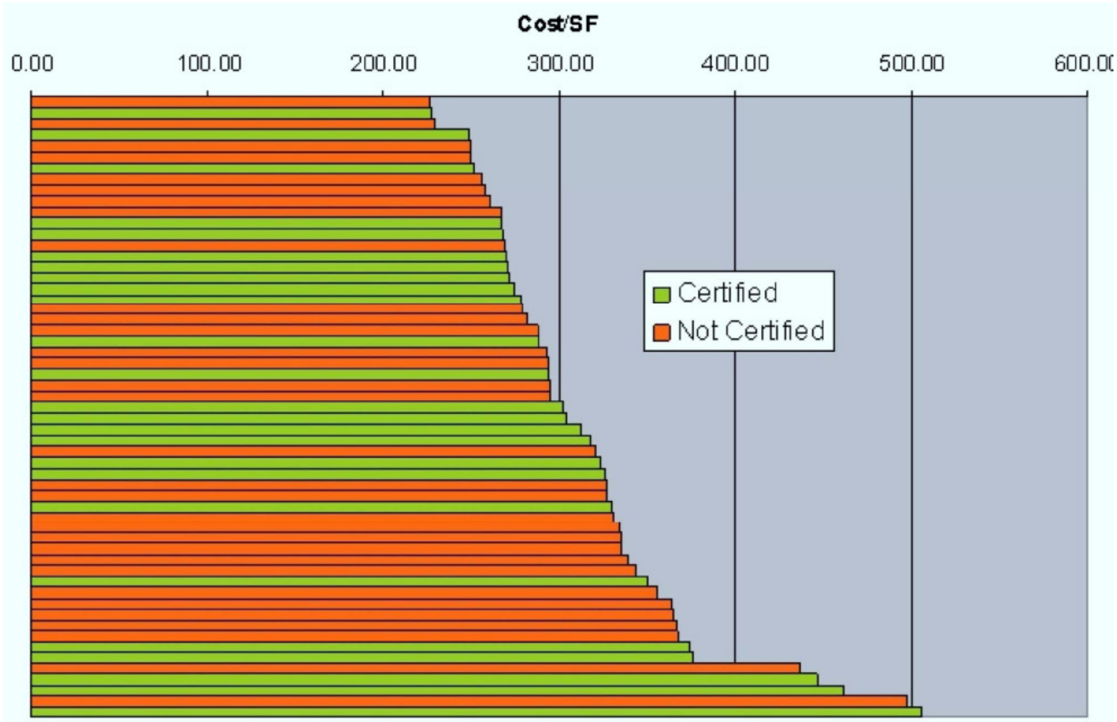


Figure 4 – Costs of certified versus non certified library buildings (Langdon, 2007)

Table 3 – Cost influencers for green building projects (Yudelson, 2009)

Cost influencer	Possible cost increases
1. Level of LEED certification sought	Zero for LEED-certified to 1-2 % for LEED Silver, up to 4% for LEED Gold
2. Stage of the project when the decision is made to seek LEED certification	After 50% completion of design development, things get more costly to change
3. Project type	With certain project types, such as science and technology labs, it can be costly to change established design approaches; designs for office buildings are easier to change
4. Experience of the design and construction teams in sustainable design and green buildings	Every organization has a "learning curve" for green buildings; costs decrease as teams learn more about the process

Cost influencer	Possible cost increases
5. Specific "green" technologies added to a project without full integration with other components	Photovoltaics and green roofs are going to add costs, no matter what; it's possible to design a LEED Gold building without them
6. Lack of clear priorities for green measures and lack of a strategy for including them	Each design team member considers strategies in isolation, in the absence of clear direction from the owner, resulting in higher costs overall and less systems integration
7. Geographic location and climate	Climate can make certain levels of LEED certification harder and costlier for project types such as labs and even office buildings.

1.3 Terminologies, concepts and tools for environmental evaluation

1.3.1 Terminologies "green versus sustainable"

Before discussing green construction rating systems, first green construction needs to be defined and distinguished from other commonly used terminologies. "Green construction" and "sustainability" are terms that are widely used in referring to environmentally friendly buildings and/or practices. Yet, a clear distinction between these terms is not common. So, in the following section, three theories on "green" and "sustainability" are introduced and explained. Then a final conclusion is drawn from them to have a full view and understanding upon what is meant by those terms in order to be able to know how to reach them later in this thesis.

- Theory #1:

In figure 5 (Yudelson, 2009) the difference between commonly used terminologies is shown on an energy use and effect on environment basis.

Figure 5 shows the Trajectory of environmentally responsible design showing a positive upward movement from conventional design through green design to fully restorative and regenerative designs. It can be concluded that green is a step towards sustainability.

A green building is defined to be "the one that considers and then reduces its impact on the environment and human health. A green building uses considerably less energy and water than a conventional building and has fewer site impacts and generally higher levels of indoor air quality. It also accounts for some measure of the life-cycle impact of choices between various types of building materials, furniture and

furnishings. Green building benefits result from better site development practices; design and construction choices; and the cumulative effects of operation, maintenance, removal and possible reuse of building materials and systems." (Marvin, 2009) . On the other hand, Sustainability is defined to be "about living today in a way that makes it possible for future generations to have as good a life as we do. It's about living in balance with the earth so resources are used sparingly and turned into products that last a long time" (Yudelson, 2010).

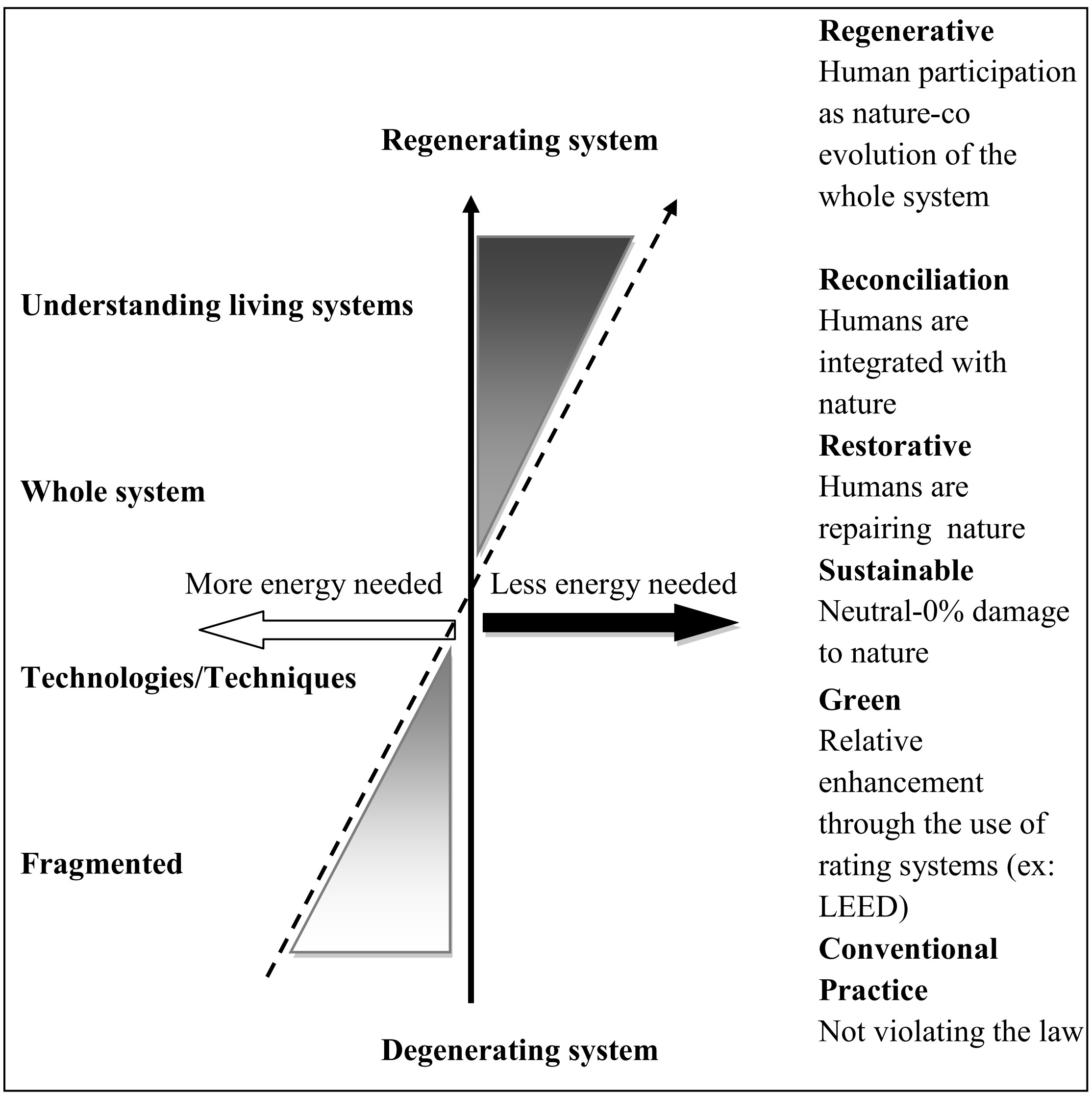


Figure 5 - Trajectory of environmentally responsible design (Yudelson, 2009)

- Theory #2:

Yet, another approach views the relationship between sustainability and green to be as shown below in figure6 (Attmann, 2010). In Figure 6 sustainability is used to describe technologically, materially, ecologically, and environmentally stable building design mainly from the economical point of view. On the other hand green is viewed as an abstract concept that includes sustainability ecology and performance. Ecology in this case is concerned with the relation and balance of the building with the nature. According to this concept a building can be sustainable (stable) with low performance or bad impact on the environment making it non green. The same goes with good performance with no ecology or stability…etc.

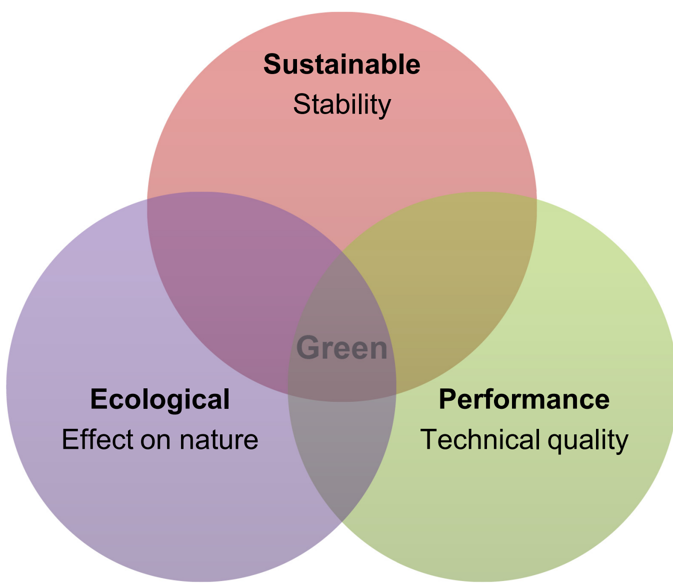


Figure 6 - Relationship between green, sustainability, ecology, and performance (Attmann, 2010)

- Theory #3:

A third approach views the pillars of sustainability to be environmental, social and economic aspects. This is shown in figure 7 (Rodriguez, Roman, Sturhahn, & Terry, 2002). From figure 7, it can be concluded that in order for a sustainable approach to work, one must consider the economic, social and environmental aspects.

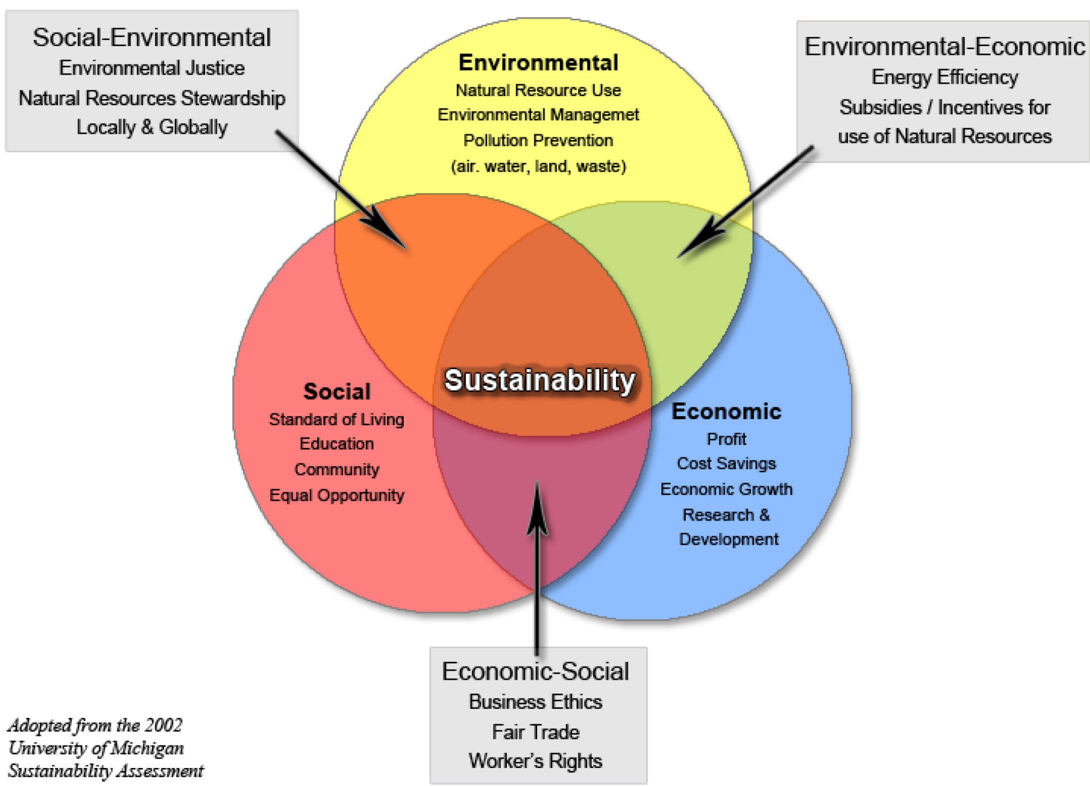


Figure 7 - Relationship between Environmental, social, economic and sustainable aspects (Rodriguez, Roman, Sturhahn, & Terry, 2002)

- Conclusion:

If all three theories are compared and integrated, one can come up with a general explanation and differentiation between all the aspects mentioned above. In theory #1, green is equivalent to the ecological aspect in theory#2, as well as the environmental aspect in theory#3 (impact on the environment). Also, Sustainability in theory#2 overlaps with the economic as well as the social aspects in theory#3 (Aspects leading to stability). Adding to that, in theory#2 the performance aspect overlaps with the economic and the environmental aspects in theory#3 (technical performance). In theory#1, Sustainability is the same as achieving green in theory#2 and achieving sustainability in theory#3. The only thing that theory#1 adds is introducing the positive effect on the environment rather than reducing the negative impact on it. So to sum up all the above mentioned theories and aspects one can say that to achieve successful Sustainability (in this case it is chosen to mean optimum building performance) several aspects are involved:

- Social
- Economic
- Environmental impact
- Technical performance
- Stability

1.3.2 Concepts for environmental evaluation

Concepts are defined as "an idea on how to achieve sustainability for the environment, such as life-cycle thinking, design for the environment, cleaner technology, etc." ((Wrisberg, Udo de Haes, Triebswetter, Eder, & Clift, 1999) *and* (Batty, Davoudi, & Layard, 2001)). The most famous environmental concepts are (Papadopoulos & Giama, 2009):

1. Life cycle thinking (LCT) concept

LCT takes into consideration the impact of any product from cradle-to grave to include environmental impacts along its whole life cycle, process or activity (Todd & Curran, 1997).

2. Life cycle management (LCM)

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

3. Design for environment

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

4. Cleaner technology

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

Cleaner production requires (a) change of attitudes, (b) environmental management and (c) evaluating technology options (Wrisberg, Udo de Haes, Triebswetter, Eder, & Clift, 1999).

5. Dematerialization

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

6. Eco-efficiency

The term eco-efficiency was introduced by the World Business Council for Sustainable Development (World Business Council for Sustainable Development (WBCSD), 1993). It is defined as "the delivery of competitively priced goods and services, which satisfy human needs and bring quality of life, while progressively reducing ecological impacts and resource intensity throughout the life cycle". Eco-Efficiency can be used as a practical approach as well as a measurable performance indicator for production because consumption processes can be calculated according to the general formula: Eco-Efficiency = Environmental impact / cost

7. Industrial ecology

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

8. End-of-Life (EOL) management

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

1.3.3 Tools for environmental evaluation

"Tools are operational methods based on concepts and supported by technical elements such as models and software" (Papadopoulos & Giama, 2009). Environmental tools may differ in their structure and technical details, but generally target complete environmental assessment. Tools are classified into analytical and operational ones.

1.3.3.1 **Analytical environmental tools**

Analytical tools study the consequences of a choice. The most popular analytical environmental tools are:

(1) life-cycle assessment (LCA)

(2) Material flow accounting (MFA)

(3) Material intensity per service unit (MIPS)

(4) Cumulative energy requirements analysis (CERA)

(5) Environmental input/output analysis (IOA)

(6) Environmental risk assessment (ERA)

(7) Checklists for eco-design, life-cycle costing (LCC)

(8) Total cost accounting (TCA)

(9) Cost-benefit analysis (CBA)

In Table 4, a summary of analytical environmental tools, regarding their scope is shown as well as the object of their analysis and also their strengths and weaknesses.

Table 4 - Comparison of analytical environmental tools, adopted from (Papadopoulos & Giama, 2009)

Tool	Scope	Object of analysis	Strengths	Weaknesses
LCA	Comprehensive evaluation of all "upstream" and "downstream" flows	Product or service	Comprehensive with respect to environmental impact connected to a function (as far as included in LCIA). Avoids problem shifting from one stage in the life cycle to another, from one sort of environmental issue to another and from one location to another. International standardization by ISO	Complex because it considers a comprehensive chain of processes and hence data intensive. Is only partly site-specific. Does not directly consider future changes in technology and demand. Does not consider rebound effects. Only known and measurable environmental impacts are considered. Requires expert knowledge

Tool	Scope	Object of analysis	Strengths	Weaknesses
MIPS	Measurement of material input at all levels	Product or service	Can be used to monitor progress in dematerialization. Evaluates all direct material impacts. Easy to perform and communicate – the symbol of the ecological rucksack is pedagogic. Using one unit for mass and energy	Only looks at the input side of the system. Toxicity and biodiversity are not accounted for. Only looking at the weight of material used might not be appropriate estimate for environmental impacts. Hidden weighting
ERA	Assessment of environmental risk, derived from substances on humans and ecosystems	Substance	Very precise tool for substance flow analysis. International standardization and recognition by OECD, EU and US-EPA	The actual risk of adverse health effects for humans can be very hard to estimate. The uncertainties in the models and in the data used tend to lead to conservative statements. To make an accurate

Tool	Scope	Object of analysis	Strengths	Weaknesses
				prediction is very time-resource requiring and data intensive. Requires expert knowledge
MFA	Assessment of the consequences of management changes for the environmental flows and stocks	Substance or material	A powerful tool for a number of policy questions. Modeling type can link various materials and substance flows through a variety of different processes	Input-related modeling on intervention level with uncertain relation to environmental impacts, which complicates the normative evaluation
CERA	Assessment of primary energy requirement from production, use and disposal	Product or service	One single indicator. Easy to perform – energy consumption is closely related to a number of adverse environmental effects	Input related to energy carriers – no other environmental effects are considered. Limited formal recognition. Documentation mainly in German. Hidden

Tool	Scope	Object of analysis	Strengths	Weaknesses
				weighting
Analytical tools for Eco design	Quantitative and easy to use analytical tools based on LCA and MIPS	Product or process	Easy-to-use tools geared for the design purpose	Simplification may overlook significant environmental effects
Environmental IOA	Measurement of final demand and intermediate demand	Product and service	Links economic and ecological impacts	Immense measurement/data problems. Environmental IOA suffers from limitations of high level of aggregation in international input–output tables
LCC	Assessment of all internal and external costs incurred throughout the entire life cycle of a product, process or activity	Product, service, process or activity	Evaluates external and internal costs. Provides one single indicator	No comprehensive model available. No general agreement on valuation method. The valuation of environmental impacts may be questioned. Even

Tool	Scope	Object of analysis	Strengths	Weaknesses
				more data requirements than LCA because of monetization. Huge uncertainty because of many valuations
TCA	Comprehensive assessment of the full range of internal costs and savings resulting from pollution prevention projects	Project or activity (environmental/ general investment options)	Uncertainty due to inclusion of probabilistic costs can be minimized by sensitivity analysis	Does not consider eco-efficiency
CBA	Assessment of net (economic) benefit of a project	Project or activity	Can uncover costs and benefits of project alternatives with a single indicator. Easy to compare analyses	The valuation of environmental impacts may be questioned. No general agreement on valuation methods. Uncertainty because of many valuations. Since the result is presented in an aggregated form.

Tool	Scope	Object of analysis	Strengths	Weaknesses
				Complex resource requirements in all respects except when the system boundary is defined very narrowly

1.3.3.2 Operational environmental tools

Procedural tools focus on measures towards environmental performance. The most popular operational tools are:

1. Environmental management system (EMS)

   This specifies how an environmental policy and its objectives can be formulated, while taking legislative needs as well as information on major environmental impacts into account. A continuous environmental improvement is the overall objective. According to ISO 14001, the EMS differentiates between five distinct steps: (1) environmental policy, (2) planning, (3) implementation and operation, (4) checking and corrective action and (5) management review.

2. Environmental audits

   As they became a part of the ISO 14000, they can be viewed as an inspection on the EMS. A set of principles and rules -including qualification criteria for

the editors- are set out in the ISO 14010 for performing both internal as well as external auditing of an EMS.

3. Environmental performance evaluation (EPE)

   Choosing, monitoring and controlling environmental indicators representing performance of a company are guided by this tool. The ISO 14030 standards differentiate between three main indicator categories: (1) environmental condition indicators, (2) operational performance indicators and (3) management performance indicators.

4. Environmental labeling

   The use of environmental labels and declaration are guided by this tool, providing transfer of information on environmental aspects of products and services, encouraging the demand and supply of the least stressing products and services to the environment.

5. Eco-design

   It is integrating environmental aspects with familiar product development process to be beneficiary for the business as well as the environment.

6. Green procurement

   This approach is different from the EU eco-labeling scheme in the sense that the latter issues environmental labels to products rather than choose products or services with less impact on the environment (energy efficient, durable, packaging, less impact on the environment from a life cycle viewpoint).

7. Total quality environmental management (TQEM)

   This tool guides planning in business to have continuous environmental performance and promotion working with other environmental tools.

8. Rating systems

   Rating systems: the most suitable tool for sustainable construction

Rating systems are environmental and management tools that focus on the construction sector and target sustainability as well as economic and social benefits (Papadopoulos & Giama, 2009). The experience and knowledge obtained from other environmental methodologies -the decision-making and management tools- are incorporated in rating systems. For example, most of them are based on the concept of Life-Cycle Analysis but are also similar to the EMS. They also include the energy audit part extending it to cover other environmental issues, such as water conservation, IAQ, materials' selection, waste management, etc.

They evaluate new and existing buildings using scoring systems, based on a benchmark for environmental performance. Sustainable design guidelines incorporate environmental issues into the different phases of a building lifetime namely design, construction as well as buildings operation. The following criterions are some of the criteria for the evaluation and selection of rating systems (Fowler & Rauch, 2006):

a) Measurability:

Knowing if the rating system uses measurable characteristics to demonstrate the extent of sustainable design incorporated into the building.

b) Applicability

It is to know if the rating system can be used for all building types (e.g. commercial, residential, offices, hospitals, etc.).

c) Availability

It is to understand the possibility of the interchangeable use of different rating systems between countries to rate the same building.

d) Development

It is to know on which methodology is the rating system based, whether on the requirements of standards and legislation or on life-cycle concept or on EMS philosophy, etc.

e) Usability

Making sure it is practical and easy to be implemented by the user, by having practical guides with separated implementation information depending on the building's type.

f) System's maturity

This criterion is related to when the system was developed, its final revision date and the number of buildings' registered and certified.

g) Technical content

This deals with the environmental aspects examined during the certification process.

h) Communicability

This ensures that a certified building is well known to outsiders at the end of the evaluation process.

i) Cost

This criterion is clearly very essential to the user (building developer, owner, inhabitant, etc.) and takes into account all the costs that arise during the buildings' certification process. All systems evaluate buildings environmentally, therefore the environmental issues examined in all of them are:

a. Site potential

To examine the site's ecology as land with low ecological value, maintain major ecological systems on the land, minimize biodiversity, etc.

b. Land use, previously used land, use of remediate contaminated land, etc.

It has to be noticed that this category is taken into consideration only when new constructions are examined.

c. Energy efficiency

Energy use and criteria for sub-metering and CO_2 impact of systems, etc.

d. Water conservation

Include criteria for metering, leakages detection, consumption reduction, etc.

1.4 THESIS OBJECTIVE AND LAYOUT

In order to decrease the large impact buildings have on the environment in Egypt, there has to be a way to assess the factors that affect the performance of a building environmentally. As shown earlier the use of rating systems is the most appropriate technique to perform this assessment. Yet, each rating system is accommodated to suite the environment for which it was designed. This is why a new special rating system that suites and matches the needs of the construction industry and environment in Egypt was needed to be developed. This thesis aims at proposing guidelines for developing this green construction rating system for Egypt.

In order to reach this goal this thesis is laid down in the following order. In Chapter 1 the problem statement was laid out by explaining the importance of going green both internationally as well as Egypt. Adding to that, the cost of going green was discussed after that as it plays an important factor in hindering applying green techniques anywhere. Then before starting on the solution, green construction, sustainability as well as other commonly used terminologies were defined and distinguished from each other. After that, environmental evaluation techniques were surveyed to explore the best option to follow. From that it was concluded that a rating system is the most common and appropriate option for buildings thus the best option

to follow. So, all the available rating systems on the market will be explored and listed later in chapter 2.

Next in chapter 3, a literature review on the methodologies used to develop green buildings rating systems is done in order to decide on what methodology to work.

Later in Chapter 4 and 5, the chosen methodology is implemented and performed, starting in chapter 4 by performing a comparison of chosen rating systems-both international and regional. Questionnaire design as well as the following analytic hierarchy process is then shown in chapter 5.

Then in chapter 6, results and analysis are performed to validate and refine the developed rating system, followed by general conclusions, remarks and recommendations for future research in chapter 7.

CHAPTER 2

LITERATURE REVIEW

RATING SYSTEMS ON THE MARKET

2.1 LIST OF RATTING SYSTEMS

The primary green building rating systems are listed below in a chronological order.

1. R-2000

In 1981, the Canadian Home Builders' association (CHBA) and the Office of Energy Efficiency (OEE) of Natural Resources Canada (NRCan) developed the R-2000 in Canada (R-2000). It is a series of technical requirements for energy efficiency, environmental responsibility, and new home performance that supplement the existing building codes. Every R-2000 home is built and certified to this standard.

2. BREEAM (Building Research Establishments' Environmental Assessment Method)

In 1990, the BRE (Building Research Establishment) developed BREEAM in the UK ((BRE: Home) *and* (BREEAM: BRE environmental assessment method)). It checks wide-ranging environmental and sustainability issues by providing building performance evaluations in eight distinct categories:

a) Management

A well-managed building has a great effect on its performance throughout the building's life e.g. from the commissioning stages all the way through to maintenance, monitoring and finding ways to improve.

BREEAM encourages effective building operation by requiring the following:

- Best practice commissioning (Inc. seasonal commissioning)
- Policies implemented at top level management
- Effective, used and maintained operating manuals
- Operational Environmental Management system

b) Health and Well-being

On average people spend 90% of their time in buildings, therefore they have a large impact on our quality of life.

In this section BREEAM awards credits where the environment is designed to maximize occupant control; for example in the following areas:

- Heating
- Lighting
- Air quality
- Noise

c) Energy

The CO_2 emitted from buildings in the UK throughout their life time equals 50% of the total UK CO_2 emissions not including CO_2 from manufacturing, transportation of construction materials and transport of people (usually to and from buildings), which increases then to 75% of the total UK CO_2 emissions.

This section of BREEAM focuses on reducing CO_2 emissions from building operations.

Issues considered within this area are:

- CO_2 emissions
- Low energy lights
- Metering
- 'A' rated white goods
- Energy management

d) Transport

This section works in combination with the Energy section to minimize CO_2 emissions from transport to and from a building.

In this area BREEAM considers:

- The location of the development
- Parking & cyclist facilities
- Access to public transport and local amenities

- Implementation of travel plans

e) Water

Clean fresh water has limited sources so we need to use it carefully. Designers/clients can persuade new building occupiers to do this.

BREEAM credits are awarded where the following measures are in place:

- Water efficient appliances (e.g. low flush toilets)
- Water metering
- Leak detection systems
- Water butts

f) Material and waste

When taking into consideration materials used in the construction industry it is important not to forget to consider the energy used to create each element in a building along with the raw materials used.

BREEAM does this by rewarding:

- Materials with a low embodied energy i.e. 'A' rated in the Green Guide to Specification
- Buildings where part or all of an existing building is being re-used (i.e. refurbishment projects)
- Responsibly resourced materials

- Use of recycled materials

g) Land use and ecology

From 1990-1998 approximately 54,000Ha of undeveloped land was changed to developed land. This is equivalent to 13,300 football playgrounds! The projected change from rural to urban uses in England between 1998 and 2016 is a further 110,000Ha.

Think carefully about the location you are building on:

- Is it Brownfield or are you rededicating a contaminated site?
- Can you make any ecological enhancements?
- Are you protecting or endangering existing ecological features?
- Are you making the best use of your building footprint?

h) Pollution.

There are a number of environmental effects of pollution ranging from acid rain, depletion of the ozone, to waste water flooding. These effects are addressed within the BREEAM pollution section.

The BREEAM pollution section encourages:

- Refrigerants and insulation with a low global warming potential
- Space heating with minimum Nox emissions
- Building in a low flood risk area and attenuation of surface water run off

- Good practice in terms of oil interceptors/filtration in car parks and other risk areas.

BREEAM uses a scoring system based on scale of pass, good, very good, excellent, and outstanding. It also uses a number based rating of 1-5 stars in some regions (i.e., Gulf).

3. SBTOOL "formerly known as GBTool" (Sustainable Building Tool)

In 1996, the Green Building Challenge (GBC) developed the SBTOOL in Canada (Greenman Sustainable Buildings - Green Building, Consulting, Education and Sales in Canada and USA). It is a customizable building rating system, which evaluates environmental and sustainability performance. This system is designed as a generic toolbox, which can be customized according to local and regional building performance requirements and needs. SBTool uses a scoring system based on scale of -1 (deficient), 0 (minimum pass), +3 (good practice), and +5 (best practice).

4. LEED (Leadership in Energy and Environmental Design)

In 1998, the US Green Building Council (USGBC) developed LEED in the USA (USGBC: LEED). It provides a rating framework for developing and evaluating high-performance green buildings. The system primarily measures six categories:

1- Sustainable site development

2- Water efficiency

3- Energy and atmosphere

4- Materials and resources

5- Indoor environmental quality

6- Innovation and design process.

LEED uses a 69-point scale system with four ratings: Platinum (52-69 points), gold (39-51 points), silver (33-38 points), and certified (26-32 points).

5. CHPS (Collaborative for High Performance Schools)

In 1999, the Collaborative for High Performance Schools developed the CHPS in the USA (CHPS.net). It facilitates the design, construction, and operation of high-performance school buildings and environments. CHPS's main criterion is to create sustainable school environments, which are not only energy- and resource-efficient but also healthy, habitable, and comfortable.

6. GREEN GLOBES

In 2000, GREEN GLOBES was developed [in the USA: Green Building Initiative (GBI) (2005), in Canada: ECD Energy and Environment Canada and BOMA Canada under the brand name "Go Green" (Go Green Plus) (2004)] (Building environmental assessments - welcome).

The Green Globes system has also been used by the continental Association for Building Automation (CABA) to power a building intelligence quotient (BIQ).

Green Globe Go Green (for existing buildings) is owned and operated by BOMA Canada. All other Green Globes products in Canada are owned and operated by ECD Energy and Environmental Canada.

The Green Building initiative owns the license to promote and further develop Green Globes in the United States. GBI is an accredited standards developer under the American National Standards Institute (ANSI), and has begun the process to establish Green Globes as an official ANSI standard.

Green Globes (GG) is an environmental building design and management tool. It provides an online assessment protocol, a rating system, and offers guidance for building design, operation, and management. GG is interactive, flexible, and generates assessment and guidance reports. The system is reportedly better suited for smaller buildings, and serves as an evaluation tool during the design process. It addresses energy, water, waste, resource use, site, hazardous materials, management, health and safety, and indoor environment.

Green Globes has two assessment levels: self-assessment and third-party verified assessment.

Within its framework, there are modules for each stage of the design process (pre-design, design, construction, commissioning).

7. BEAM (Building Environmental Assessment Method)

In 2002, the Business Environment Council (BEC), and HK-Beam Society developed BEAM in Hong Kong (HK BEAM Society). It evaluates and measures the environmental performance of buildings in Hong Kong. The evaluation is based on five building performance criteria:

1- Hygiene, health, comfort, and amenity

2- Land use, site impact, and transportation

3- Use of materials, recycling, and waste management

4- Water quality, conservation, and recycling

5- Energy efficiency, conservation, and management.

BEAM uses an overall assessment rating system based on gained credit percentage scale. Accordingly, BEAM awards four rating classifications: platinum (excellent, 75%), gold (very good, 65%), silver (good, 55%), and bronze (above average, 40%).

8. GGHC (Green Guide for Health Care)

In 2003, the American Society for Healthcare Engineering (ASHE) developed GGHC in the USA (GGHC - home). GGHC is the healthcare sector's first quantifiable, sustainable design evaluation tool. It integrates environmental and health principles and practices into the planning, design, construction operations, and maintenance of healthcare facilities. In addition to specialized guidelines and evaluation procedures, GGHC uses the LEED system as their existing building-rating mechanism.

9. GREEN STAR (Green Star Building Evaluation System)

It was developed in Australia. It was developed by the Green Building Council of Australia, Green Star New Zealand, and Green Star South Africa. It is a comprehensive, national, voluntary rating system that evaluates a building's environmental design and performance (Green Building Council Australia (GBCA)). Green Star is modeled after BREAM; it uses a customizable rating tool kit that can be

modified for different building types and functions. Green Star ratings are based on a percentage score across nine performance categories:

1- Management

2- Indoor environment

3- Energy

4- Transportation

5- Water

6- Materials

7- Land use and ecology

8- Emissions and innovation.

10. CASBEE (Comprehensive Assessment System for Building Environmental Efficiency)

In 2004, the Japan Green-Build Council (JaGBC) and the Japan Sustainable Building Consortium (JSBC) developed CASBEE in Japan. CASBEE measures the sustainability and environmental efficiency of high-performance buildings (CASBEE). Green building issues and problems that are unique to Japan and Asia are especially taken into consideration.

CASBEE has four grading categories (pre-design, new construction, existing buildings, and renovations), which are evaluated based on four criteria:

1- Energy

2- Site

3- Indoor environmental quality

4- Resources, materials, and water conservation.

An overall evaluation rating is determined based on numerous calculations, and the results are presented in a letter scale of S (excellent), A, B+, B-, and C (poor).

11. HQE (Haute Qualite' Environnementale “high Quality Environmental Standard”)

In 2004, It was developed by the ASSOHQE (Association pour la Haute Qualite' Environnemnentale) in France (Association HQE). HQE evaluates the environmental impact of buildings, focusing on the following criteria:

1- Design

2- Construction

3- Energy

4- Water, waste, and maintenance.

12. NGBS (National Green Building Standard)

In 2005, the NAHB (National Association of home builders) developed the NGBS in the USA (NAHBGreen). It provides guidelines for the mainstream homebuilder to incorporate environmental concerns into a new home. Divided into two parts, the system covers seven evaluation criteria:

1. Lot design

2. Resource efficiency
3. Energy efficiency
4. Water efficiency
5. Indoor environmental quality
6. Homeowner education
7. Global impact.

13. NABERS (National Australian Built Environment Rating System)

In 2005, the NSW (New South Wales Government), Department of Environmental and Climate Change, Australia developed the NABERS in Australia which measures existing buildings' performance during their life cycles (NABERS - home page). There are separate ratings for: office buildings, office occupants, hotels, and homes. Final ratings are based on measured operational impacts of four evaluation criteria:

1- Energy
2- Water
3- Waste management
4- Indoor environment.

14. GRIHA (India Green Rating for Integrated Habitat Assessment)

In 2005, the TERI (Energy and Resources Institute) developed GRIHA, which measures the environmental performance of buildings, focusing on India's varied climate and building practices (TERI - The Energy and Resources Institute) in India. The rating is based on quantitative and qualitative assessment techniques, and is applicable to new and existing buildings (commercial, institutional, and residential). The evaluation criteria are:

1- Site planning
2- Building envelope design
3- Building system design
4- HVAC
5- Lighting and electrical
6- Integration of renewable energy sources to generate energy onsite
7- Water and waste management
8- Selection of ecologically sustainable materials
9- Indoor environmental quality.

15. BCA Green Mark (Singapore Building and Construction Authority Green Mark)

In 2005, the Singapore Building and Construction Authority and the National Environment agency developed the BCA Green Mark in Singapore, which is a green building rating system that evaluates a building for its environmental impact and performance (BCA green mark). It provides a comprehensive framework for assessing building performance and environmental friendliness. Buildings are awarded the BCA Green Mark based on five key criteria:

1- Energy efficiency
2- Water efficiency
3- Site/project development and management (building management and operation for existing buildings)
4- Indoor environmental quality and environmental protection
5- Innovation.

16. THREE STAR (Green Building Evaluation standard)

In 2006, the ministry of construction and the ministry of housing and urban rural development developed the THREE STAR as China's first building rating system (Geoff, 2009) and (Ministry of construction - china.org.cn) in China. It is designed to create local building standards. It is a credit-based system with two standards-residential and commercial. The system evaluates the building in six categories:

1- Land savings and outdoor improvement
2- Energy saving
3- Water savings
4- Material savings
5- Indoor environmental quality
6- Operations and management.

17. GBAS (Green Building Assessment System)

In 2006, the Ministry of Science and Technology (MoST) developed the GBAS in China, which is developed from China's Green Olympic Building Assessment System (GOBAS,2006), and measures basic environmental performance of buildings such as: electricity, water, and energy consumption.

18. GSBC (German Sustainable Building Certification)

In 2009, the German Sustainable Building Council (DGNB) developed the GSBC in Germany (DNGB german green building council). It is a comprehensive rating system, which covers all relevant topics of sustainable building and construction. It

was developed as a tool for the planning and evaluation of buildings, using six categories with 49 criteria:

1- Ecological quality
2- Economical quality
3- Socio-cultural and functional quality
4- Technical quality
5- Quality of the processes
6- Site

GSBC uses a number-based system, in which each category has an equal percentage weight. Three evaluation degrees are offered: Gold (89%), Silver (69%), and Bronze (50%).

19. LEED V3 Jordan

In 2009, the Jordan green building council decided to use the LEED V3 for rating green buildings in Jordan (The future home of jordan green building council).

20. Thermal standard for buildings in Lebanon

In 2010, the LGBC (Lebanon Green Building Council) developed the Thermal Standard for Buildings in Lebanon (LGBC, 2010).

21. ESTIDAMA - Pearls Rating System

The ESTIDAMA Pearl Rating System was developed by the Abu Dhabi Urban Planning Council. The system was launched in September 2010 (Estidama). Pursuing a rating under this program is completely voluntary. The rating method includes both

prerequisites and voluntary credits. The prerequisites will be encoded in one of three regulatory processes

1. The Urban Planning Council (UPC) Planning Approval Process
2. The UPC Framework Development Regulations (released in the latter half of 2009)
3. The ongoing update of the Abu Dhabi Building code

The Pearl Rating System for ESTIDAMA aims to address the sustainability of a given development throughout its lifecycle from design through construction to operation. It provides design guidance and detailed requirements for rating a project's potential performance in relation to the four pillars of ESTIDAMA.

The Pearl Rating System is organized into seven categories where there are both mandatory and optional credits. To achieve a 1 Pearl rating, all the mandatory credit requirements must be met. To achieve a higher Pearl rating (2-5 Pearls), all the mandatory credit requirements must be met along with a minimum number of credit points. In figures 8, 9 and 10 the weights for the three rating systems of ESTIDAMA are shown.

The Pearl Rating System for ESTIDAMA categories are:

1- Integrated Development Process (IDP)
2- Natural Systems
3- The Livable Buildings
4- Livable Communities

5- Precious Water

6- Resourceful Energy

7- Stewarding Materials

8- Innovating Practice

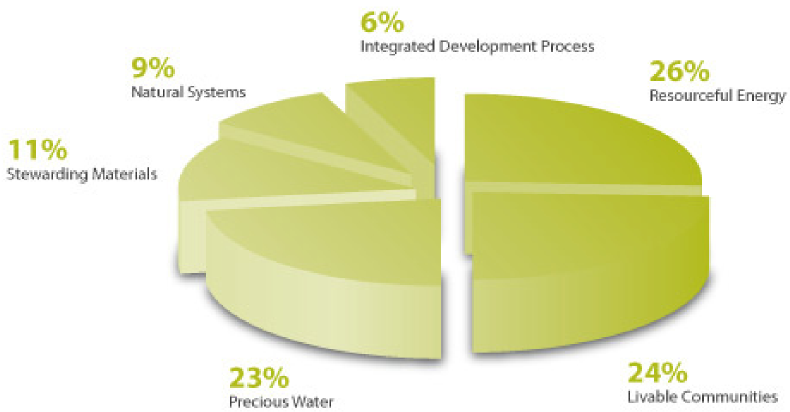


Figure 8 - Pearl Community Rating System Weighting (Estidama)

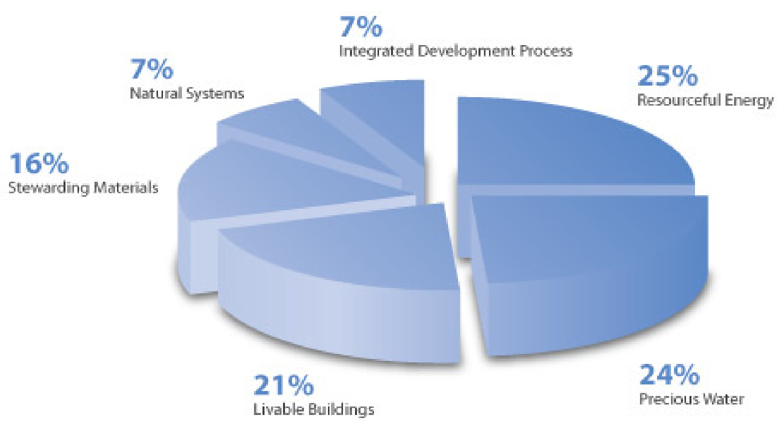


Figure 9 - Pearl Building Rating System Weighting (Estidama)

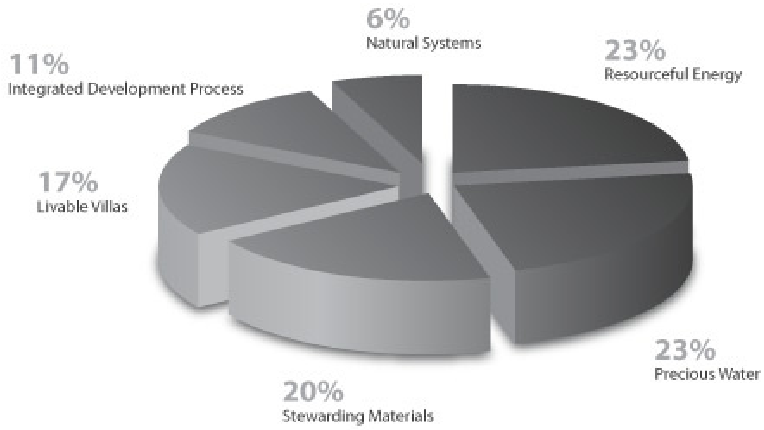


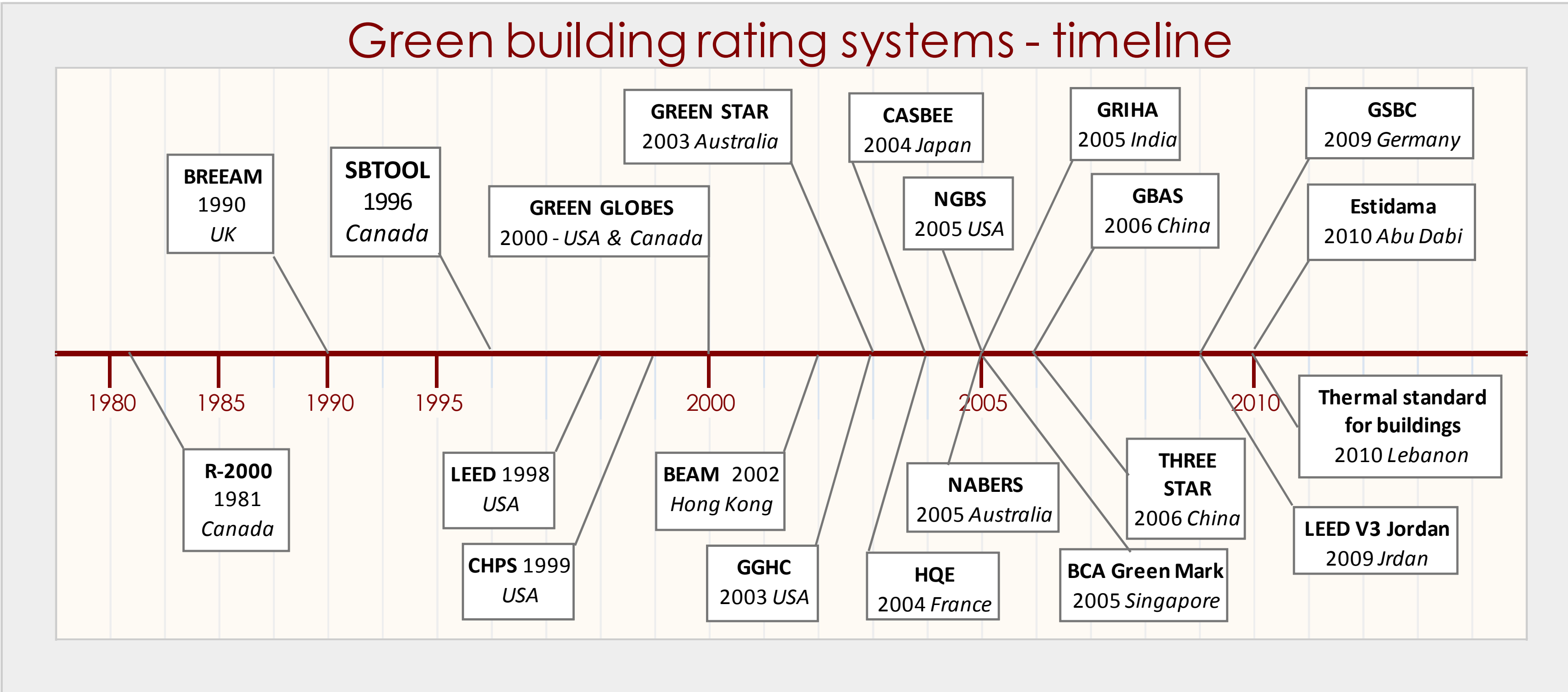
Figure 10 - Pearl Villa Rating System Weighting (Estidama)

2.1.1 SUMMARY

In figure 11, the timeline of developing green building rating systems throughout the world is summed up. This was developed by using the above mentioned information on each rating system.

It is can be concluded from figure 11 that several developed countries are the major contributors in this field, while developing countries- such as India, Lebanon and Jordan - are a bit new to that race due to economic and social difficulties or lack of proper plans to make sure those guidelines are properly implemented. (Potbhare, Syal, Arif, Khalfan, & Egbu, 2009). It can also be concluded that every country aims at developing a rating system that suites its environment and construction market. This proves that a special rating system for Egypt needs to be developed.

Figure 11 - green building rating systems - timeline



2.2 LITERATURE ON GREEN BUILDING RATING SYSTEMS

In this part, articles that discussed some of the rating systems mentioned earlier are explored and shown below.

- **R-2000**

"R-2000 houses consume about 31% less space heating energy than new conventional housing. Increasing air tightness has developed a need for dedicated mechanical ventilation systems for preventing indoor air quality problems in conventional houses " (Gusdorf & Parekh, 2000). "The houses are super insulated, ultra tight, have controlled ventilation with heat recovery, do not implement lots of glass, good lighting and anything that is off-the-shelf. Most importantly, they can be built by anyone. These houses teach builders to set performance metrics that are matched with present materials and current understanding of building science" (Lstiburek, 2008).

"Canada has established now a new program to encourage sustainability in housing. The Advanced Houses Program is taking over where R-2000 left off, by encouraging technologies which minimize the environmental impact of houses as well as making them even more energy efficient focusing on resource conservation, construction waste reduction, water and sewage reduction, recycled materials, in-house recycling facilities, and low-emission finishes" (Mayo, 1996). "At present, Canadian homes are more energy efficient than their earlier counterparts because of the Advanced Houses Program. The program enables the Canadian residential construction industry to build houses whose annual total purchased energy load is well below R-2000 levels, and as low as 17 watt-hrs./m2/heating degree day" (Mayo & Sinha, 1997).

- **BREEAM (Building Research Establishments' Environmental Assessment Method)**

"BREEAM was launched by the Building Research Establishment (BRE) to provide a means to evaluate the environmental performance of buildings. BREEAM assesses buildings against a range of environmental issues and awards credits where the building achieves a benchmark performance for each issue. The scheme is regularly updated to take advantage of new research, changing priorities and experience in the market place and amendments to regulations " (BREEAM - making better buildings, 1999).

"BREEAM is deemed as the most successfully executed program for promoting sustainable building practices and influencing other initiatives worldwide. Each building, under the BREEAM program, is awarded credits for achieving particular performance targets within certain areas such as management, energy transport, water, pollution, and land use and ecology. A BREEAM assessed development can mean functionality, flexibility, durability, minimized sum of embodied and operational impacts, and high user satisfaction, quality, and control. BREEAM also allows design team, planners, and development agencies to specify the sustainability performance of their buildings in a way that is quick, comprehensive, and visible in the marketplace" (Mistry, 2007). "Its success is largely due to a benchmarking approach; comprehensive coverage of issues related to energy, environmental impact, and health and productivity; and the identification of realistic opportunities for improvement as well as potential additional financial rewards" (SHopek, 1999).

“In an assessment of a building incorporating a number of sustainability features using two different building rating systems (the UK Building Research Establishment Environmental Assessment Method (BREEAM) and the international Leadership in Energy and Environmental Development (LEED), as developed by the Canada Green Building Council) are described. The building scored well under both systems, although the credits achieved were more equally distributed in the LEED Canada assessment than under BREEAM. A number of differences between the schemes are highlighted; the categories achieving the highest percentage credits under both tools were water, energy and occupant health. The paper (Fenner & Ryce, 2008) concludes that, while the two schemes may differ in name, applications style and ranking mechanisms, the tools are more similar than dissimilar and provide broadly comparable assessments”.

- **LEED (Leadership in Energy and Environmental Design)**

In 1992, a UN conference on Environmental Development held in Rio de Janeiro reintroduced the concept of "sustainability"(advanced by the United Nations Commission on Environment and Development [UNCED] in 1987) and defined it as: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." A year later the U.S. Green Building Council was established to formalize this concept by developing a green rating system - "Leadership in Energy and Environmental Design" (LEED), applicable to new and renovated buildings. The system utilizes 69 certification points dealing with sustainable sites, water efficiency, energy and atmosphere, materials and resources, air quality and innovation (Abood, 2007).

LEED-EB system works for many building types including schools, laboratories, hostels and office buildings. The system focuses on building performance and environmental impact. It covers both existing building and building previously certified under LEED-NC. The LEED-EB rating also helps in solving building operation problems, reduce building operation costs and improve indoor environment “quality for occupants (Arny, 2004).

For projects pursuing LEED certification, designers have to conduct in-depth sustainability analyses based on a building's form, materials, context, and mechanical-electrical-plumbing (MEP) systems. Since Building Information Modeling (BIM) allows for multi-disciplinary information to be superimposed within one model, it creates an opportunity to conduct these analyses accurately and efficiently as compared to the traditional methods. Documentation supporting LEED credits may be directly or indirectly prepared using the results of BIM-based sustainability analyses software. This process could streamline the LEED certification process and save substantial time and resources, which would otherwise be required using traditional methods.” (Azhar, Carlton, Olsen, & Ahmed, 2010).

“It has been noted that to achieve any LEED rating it is necessary to incorporate a fundamental level of commissioning into the project. A LEED-accredited professional can lead a project team through the re-commissioning management manual” (Ellis, 2003).

- **CHPS (Collaborative for High Performance Schools)**

This point-based system defines a high performance school as site, energy, material, and water efficient, as well as healthy, comfortable, and easy to maintain

and operate. Design considerations include safety concerns, accessibility requirements, fire codes and fire lanes, real estate limitations, and the cost of maintenance. Just as the storm water facilities must achieve water quality goals, they must also maintain a safe environment, be aesthetically pleasing to staff and students, and comply with the Americans with Disabilities Act requirements (Anchipolovsky, Balaa, Wang, Austin, & Havens, 2010).

- **GREEN GLOBES**

The Green Building Institute's (GBI's) Green Globes can offer specific advantages in terms of affordability and user-friendliness, making it well-suited for smaller, financially limited projects that want to quantify green construction and operation (Skopek, 2006).

- **BEAM (Building Environmental Assessment Method)**

To maintain relevance, Hong Kong Building Environmental Assessment Method (HK-BEAM) for residential buildings should be periodically updated to incorporate new environmental data, so extensive research on energy and environmental performance should be performed for high-rise residential buildings found in Hong Kong. This embraces various aspects such as building wall, door, window, and shading characteristics, and utilization in time and space patterns of activities in residential units. In this paper various design tools are described, simulation procedures outlined. Preliminary results show energy savings of roughly 8% for an optimally placed insulation, and lower cooling demand of 14% for a provision of additional concrete in the building envelope (Bojic, Burnett, & Yik, 2001).

In the Hong Kong Building Environmental Assessment Method (HK-BEAM), lighting forms a significant part of the assessment. Assessment of lighting consists of two main items: energy consumption, and indoor lighting quality. It has been noted that the day lighting criteria in the current version of HK-BEAM are difficult to achieve (Chung & Burnett, 1999).

- **GREEN STAR (Green Star Building Evaluation System)**

"The building and construction industry in Australia has taken significant steps forward in the last 3-5 years to improve their environmental performance. This improvement has been in response to increased focus of local/state government policies regarding Ecological Sustainable Development (ESD), as well as the availability of holistic environmental rating tools such as the Green Building Council of Australia's Green Star rating tools. However the unique climatic conditions of Australia, which range from hot arid to cool temperate combined with its expansiveness generate considerable challenges to building designers in achieving environmentally responsive and sustainable buildings. In addition, designers are increasingly being engaged to contractually meet minimum environmental performance requirements that extend beyond energy conservation/greenhouse performance to cover issues such as water conservation, environmentally credible material selection, indoor environmental quality, transport, ecology and pollution as well as on-going environmental management of facilities" (McCabe, 2006).

Green Star has significant implications on almost every aspect of the design of HVAC systems, including the selection of air handling and distribution systems,

fluid handling systems, refrigeration systems, heat rejection systems and building control systems (Guan & Chen, 2009).

- **CASBEE (Comprehensive Assessment System for Building Environmental Efficiency)**

“CASBEE (Comprehensive Assessment System for Building Environmental Efficiency) is an environmental labeling method for buildings, based on assessment of the environmental performance of buildings. In CASBEE, BEE (Building Environmental Efficiency) was developed as a new indicator for assessment following the concept of eco-efficiency. With the increasing BEE value, the total environmental performance of buildings is labeled from the highest performance. The framework of basic and extended CASBEE tools as a structured assessment system is called the "CASBEE family." CASBEE consists of a set of four basic assessment tools; namely, "CASBEE for Pre-design" (CASBEE-PD), "CASBEE for New Construction" (CASBEE-NC), "CASBEE for Existing Building" (CASBEE-EB) and "CASBEE for Renovation" (CASBEE-RN). These correspond to the individual stages of the building's lifecycle. There are also needs for detailed assessment targeting specific environmental aspects. "CASBEE-HI," as an extended tool, assesses efforts made in buildings to alleviate the heat island effect. A new tool called "CASBEE for Urban Development" (CASBEE-UD) is developed for assessment of a group of buildings. Some local authorities introduced CASBEE into their building administration as assessment methods for their sustainable building reporting systems. This requires building owners to submit a planning document assessing the environmental performance of their buildings to the authorities. In April 2004, the city of Nagoya introduced "CASBEE Nagoya." Introduction of CASBEE followed in the city of Osaka,

Yokohama, Kyoto and other municipals. These local systems require some modification in CASBEE to reflect their local characteristics, such as climate and prioritized policies." (Endo, Murakami, & Ikaga, 2008).

"In Japan, a new assessment system called CASBEE-HI (Comprehensive Assessment System for Building Environmental Efficiency on Heat Island Relaxation) has been developed for evaluation of the effects of various building design-related measures for heat island reduction. To assist the evaluator to examine the wind environment, a wind environment database was developed" (Oguro, Morikawa, Murakami, Matsunawa, & Mochid, 2008).

- **GBAS (Green Building Assessment System)**

There are unbalanced regional characteristics of green building in China. Therefore analyzing the regional characteristics of the building and adjusted weights of regional factors to establish scientific green building assessment system with local characteristics is needed to be considered urgently (Li, 2010).

- **GSBC (German Sustainable Building Certification)**

"55% of all investments are made in the buildings sector. Over its entire value added chain, the construction industry accounts for 11% of output in Germany and employs 12% of the workforce subject to compulsory social insurance. The construction, housing and property sectors are involved in a multiplicity of interrelationships with measures and objectives of the Federal Government's sustainable development strategy. Principal among these are climate change mitigation, improving energy efficiency, improving the productivity of energy and raw materials, reducing land take and shaping demographic change.

The assessment of the contribution made by individual structures to sustainable development results in the call for the development of an overall system for the description and appraisal of buildings, including the land on which they are built. Sustainability considerations are characterized by a whole life cycle analysis and the comprehensive inclusion of ecological, economic and socio-cultural aspects. Alongside energy balances, therefore, it is also necessary to study the material flows and financial impacts, in particular. The development, trialing and application of systems for describing, assessing and certifying the sustainability of buildings is tied to a number of prerequisites.

In particular, the changeover to an assessment and certification system based predominantly on quantitative assessments poses a significant challenge. The new sustainable construction assessment system that has been developed in Germany is a voluntary market instrument and is currently designed for office and administrative buildings, and has been trialed on such buildings. It is available to all users free of charge and can be downloaded from the following website: www.nachhaltigesbauen.de.

The Federal Government plans to make the system mandatory for federal buildings by introducing it with the Sustainable Construction Guide via the federal building authorities, thereby setting an example of good practice. The system can be used by other providers. Widening it to include other categories of buildings will be done by appropriate system providers. These providers can have their system recognized by the Bundesministerium fur Verkehr, Bau- und Stadtentwicklung (BMVBS; Federal Ministry of Transport, Building and Urban Development). In the case of buildings and structural works that are of significant public interest, assessment systems will be developed and implemented in

working groups comprising representatives of public agencies and hosted by the BMVBS. Ernst Sohn Verlag fur Architektur und technische Wissenschaften GmbH Co. KG, Berlin” (Henger, 2010).

- **Multiple ratings comparisons**

In table 5 and 6, examples of comparisons performed between different rating systems are shown. In these articles the authors compared the rating system on different factors such as main categories as well as the sub-categories covered in each of them. Also rating systems were compared upon the weights they gave for each main category in comparison to each other. They were compared also upon their origin and accreditation levels.

Table 5 - Comparative analysis of LEEDw NC-USA, BREEAM-UK, and CASBEE-Japan (Egbu, Potbhare, Syal, Arif, & M., 2009)

Description	LEED®-NC (USGBC 2008)	BREEAM (BRE -2007)	CASBEE (JSBC -2007)
Parent Organization	U.S. Green Building Council	Building Research Establishment Ltd.	Japan Sustainable Building Consortium
Country	U.S.	U.K.	Japan
Year of Origin	2000	1990	1998
Type of Ratings	Platinum - 52 to 69 Gold - 39 to 51 Silver - 33 to 38 Certified - 26 to 32	Pass - 25 to 39% Very Good – 40 to 54% Good - 55 to 69% Excellent - 70% and above	BEE 3.0 and above BEE 1.5 to 3.0 BEE 1.0 to 1.5 BEE 0.5 to 1.0 BEE 0 to 0.5
Major Divisions, Categories, Sub Categories	Sustainable Sites Pre requisite: Construction activity pollution prevention Credit 1: Site selection Credit 2: Development density and community connectivity Credit 3: Brownfield redevelopment Credit 4.1: Alternative transportation: Public transportation access Credit 4.2: Alternative transportation: Bicycle storage and changing rooms Credit 4.3: Alternative transportation: Low emitting and fuel efficient vehicles Credit 4.4: Alternative transportation: Parking capacity Credit 5.1: Site development: Protect and restore habitat Credit 5.2: Site development: Maximize open space Credit 6.1: Stromwater design: Quantity control	Management BREEAM encourages effective building operation by requiring the following: • Best practice commissioning (inc. seasonal commissioning) • Policies implemented at top level management • Effective, used and maintained operating manuals • Operational environmental management system Health and Well Being In this section BREEAM awards credits where the environment is designed to maximize occupant control; for example in the following areas:	Q-1 Indoor Environment 1 Noise and acoustics 1.1. Noise 1.2. Sound insulation 1.3.Sound absorption 2. Thermal comfort 2.1. Room temperature control 2.2. Humidity control 2.3. Type of air conditioning systems 3. Lighting & illumination 3.1. Day lighting 3.2. Anti glare 3.3. luminance level 3.4. Lighting controllability

	Credit 6.2: Stromwater design: Quality Control Credit 7.1: Heat island effect: Non-roof Credit 7.2: Heat island effect: Roof Credit 8: Light pollution reduction <u>Water Efficiency</u> Credit 1.1: Water efficient landscaping: Reduce by 50% Credit 1.2: Water efficient landscaping: No potable use or no irrigation Credit 2: Innovative wastewater technologies Credit 3.1: Water use reduction: 20% reduction Credit 3.2: Water use reduction: 30% reduction <u>Energy & Atmosphere</u> Pre requisite 1: Fundamental commissioning of building energy systems Pre requisite 2: Minimum energy performance Pre requisite 3: Fundamental refrigerant management Credit 1: Optimize energy performance Credit 2: On-site renewable energy Credit 3: Enhanced commissioning Credit 4: Enhanced refrigerant management Credit 5: Measurement and verification Credit 6: Green power	· Heating · Lighting · Air quality · Noise <u>Energy</u> This section of BREEAM focuses on reducing CO2 emissions from building operations. Issues considered within this area are: · CO_2 emissions · Low energy lights · Metering · 'A" rated white goods · Energy management <u>Transport</u> In this area BREEAM considers: · The location of development · Parking and cyclist facilities · Access to public transport and local amenities Implementation of travel plans	4. Air Quality 4.1. Source control 4.2. Ventilation 4.3. Operation plan <u>Q-2 Quality of Service</u> 1. Service ability 1.1. Functionality and usability 1.2. Amenity 2. Durability & reliability 2.1. Earthquake resistance 2.2. Service life of components 2.3. Reliability 3. Flexibility and adaptability 3.1. Spatial margin 3.2. Floor load margin 3.3. Adaptability of facilities <u>Q-3 Outdoor Environment On site</u> 1. Preservation and creation of biotope 2. Townscape and landscape 3. Local characteristics and outdoor amenity 3.1. Attention to local character and improvement of comfort 3.2. Improvement of the thermal environment of site

	Material & Resources Pre requisite 1: Storage and collection of recyclables Credit 1.1: Building reuse: Maintain 75% of existing walls, floors and roof Credit 1.2: Building reuse: Maintain 95% of existing walls, floors and roof Credit 1.3: Building reuse: Maintain 50% of interior non-structural elements Credit 2.1: Construction waste management: Divert 50% from disposal Credit 2.2: Construction waste management: Divert 75% from disposal Credit 3.1: Material reuse: 5% Credit 3.2: Material reuse: 10% Credit 4.1: Recycled content: 10% (post consumer + ½ pre consumer) Credit 4.2: Recycled content: 20% (post consumer + ½ pre consumer) Credit 5.1: Regional materials: 10% Extracted, processed and manufactured regionally Credit 5.2: Regional materials: 20% Extracted, processed and manufactured regionally Credit 6: Rapidly renewable materials Credit 7: Certified wood Indoor Air Quality Pre requisite 1: Minimum IAQ performance Pre requisite 2: Environmental tobacco smoke control	Water BREEAM credits are awarded where the following measures are in place: • Water efficient appliances (e.g. low flush toilets) • Water metering • Leak detection systems • Water butts Material and Waste BREEAM does this by rewarding: • Materials with a low embodied energy i.e. 'A' rated in the Green Guide to specification • Buildings where part or all of an existing building is being reused (i.e. refurbishment projects) • Responsibly resourced materials • Use of recycled materials Land use and Ecology Think carefully about the location of your building on site:	Building Environmental Loadings (LR) LR 1 Energy 1. Building thermal load 2. Natural energy utilization 2.1. Direct use of natural energy 2.2. Converted use of renewable energy 3. Efficiency in building service system 3.1. HVAC system 3.2. Ventilation system 3.3. Lighting system 3.4. Hot water supply system 3.5. Elevators 3.6. Equipment for improving energy efficiency 4. Efficient operation 4.1. Monitoring 4.2. Operational management system LR – 2 Resources & Materials 1. Water resources

Table 6 - Rating systems' weighting comparison (SAUNDERS, 2008)

	BREEAM	LEED	Green Star	CASBEE
Management	15	8	10	It is not possible to calculate the value of each issue category, for CASBEE, as the value is dependant on the final score
Energy	25	25	20	
Transport			10	
Health and Wellbeing	15	13	10	
Water	5	5	12	
Materials	10	19	10	
Landuse and Ecology	15	5	8	
Pollution	15	11	5	
Sustainable Sites	-	16	-	

CHAPTER 3

LITERATURE REVIEW

DEVELOPING GREEN BUILDING RATING SYSTEMS

In the first two chapters, the basics concerning green buildings and their rating systems around the globe were explored. This chapter is mainly a review on the different methodologies of developing rating systems that were mentioned in different articles. This is to be able to decide on how to develop an Egyptian green building rating system. It can be noticed later in this chapter that there are mainly three articles that were used here on the basis of their relevancy. One article performs a comparative analysis while the other two use questionnaires and surveys along with AHP analysis to develop the weights of different items that affect the performance of green buildings. Only the methodologies used were discussed due to the fact that each system was uniquely designed to match the country it was developed for so their results were irrelevant to this thesis.

3.1 COMPARATIVE ANALYSIS

In that article (Papadopoulos & Giama, 2009) rating systems were compared, similarities and differences were analyzed and a joint evaluation guide for existing buildings derived for Greece as a result of the rating systems' analysis. Criteria

for rating systems' evaluation were set, while the most representative rating systems such as BREEAM and LEED were implemented to office building in Greece.

Choice of rating systems to compare

- The rating systems examined were:

GB TOOL

BREEAM

LEED

CASBEE

Green Globes US

Comparative analysis

1. The focus was on trying to work out how well a UK building might score against BREEAM, if it was designed to meet the requirements of the alternative schemes covered.
2. Each of the schemes was investigated to identify criteria covering similar issues to those covered by BREEAM. Each of the criteria in the alternative schemes was then sorted according to the BREEAM criteria that each was equivalent to.
3. Where equivalent criteria were identified in the other schemes the compliance requirements were compared with the requirements of BREEAM in order to see which scheme has the most stretching/stringent requirements.
4. Credits were then ‘awarded’ in the scheme which had the lowest performance requirements, and ‘withheld’ where one or more of the compliance requirements were not covered by the requirements of the other schemes.
5. The relative ‘value’ or contribution to the final score was included in this table so that the total score could be calculated once each credit had been assessed in this way.

Then they compared how each of the ratings in the alternative assessment methods would compare with the equivalent ratings in BREEAM, if used to assess a building in the UK.

1. Credits were awarded, in the alternative scheme, in order of easiest / cheapest first (from a UK perspective). Any credits in the alternative scheme, that would be achieved by meeting the UK regulatory minimum or standard practice was awarded first.
2. Once a credit in the alternative scheme had been awarded the compliance requirements of the equivalent BREEAM credit were reviewed and compared to the compliance requirements of the credit in the alternative scheme.
3. If the requirements of the criteria in the alternative scheme where more stringent than the equivalent criteria in BREEAM, the equivalent BREEAM credit was awarded as a building designed to meet the criteria in the alternative scheme would meet the requirements of the BREEAM credit by default.
4. As each rating level in the alternative scheme was reached, the corresponding BREEAM rating could then be calculated by adding up the value of each BREEAM credit awarded.

Normalization Process

In order to smooth out the differences due to the local issues and standard practices, a normalization factor was calculated.

1. Credits where identified in the alternative schemes which are not covered by BREEAM and those that are in BREEAM, but not covered by the alternative schemes. The list of credits that this relates to is set out in Appendix B.
2. Once the list of credits had been identified the total value of these credits was calculated in order that a normalization factor could be calculated.
3. The normalization factor was applied to the score that could be achieved. This therefore gives a fairer comparison and better indicates the maximum score that is likely to be achieved by designing a building to meet the requirements of a one assessment method when compared to another.

3.2 QUESTIONNAIRES

The first article chosen here that discussed this methodology (Mezher, 2006) wanted to investigate the role that the construction industry is playing in the sustainable development management globally and in Lebanon particularly.

- Survey questionnaires were distributed to main construction industry players:
    1. Contractors,
    2. Architects/Engineers and
    3. Owners/Developers
- A total of 100 surveys were distributed (45 contractors, 40 A/Es and 15 O/Ds). Exactly half of which responded (22 contractors, 21 A/Es and seven O/Ds) totaling 50 participants. The respondents were selected so as to represent firms having very good standing and current major construction work in Lebanon. The annual gross revenue for the surveyed O/Ds ranged from US$5 million up to more than US$150 million and the number of employees ranged from fewer than 10 to more than 500. As for the surveyed A/Es the annual gross revenues were much less and ranged from US$120 000 up to US$40 million while same range of employee number as the O/Ds prevailed. The surveyed contractors on the other hand had a larger number of employees and annual gross revenues ranging from US$1.5 million up to more than US$1.3 billion.
- The importance index as previously defined was computed using SPSS Software.

Another article (Ali & Al Nsairat, 2009) also did a survey and an AHP analysis later on.

- The purpose of that research was developing an effective green building rating system for residential units in Jordan. That article was chosen because it demonstrated a methodology used to develop a green building rating system for a country in the region. The results of that article were not included because -as

explained earlier- each rating system is designed to suite the environment and special circumstances of the country it was developed for.

- It studied international green building assessment tools such as LEED, CASBEE, BREEAM, GBTool, and others.
- It defined new assessment items respecting the local conditions of Jordan and discussed them with (60) various stakeholders; 50% of them were experts of sustainable development.
- After selecting the assessment items they were weighted using the AHP method.
- The outcome of the research was a suggested green building assessment tool (SABA Green Building Rating System) – computer based program – that suits the Jordanian context in terms of environmental, social and economic perspectives.

3.3 Steps and methodology needed to reach the objectives

From the methodologies explored earlier, the steps chosen to have guidelines for developing a green construction rating system in Egypt, can be summed up in 2 stages:

1. Developing a list of credits that cover almost all the available aspects in buildings that have an effect over the environment.
2. Developing weightings that suite the Egyptian market.

To reach the above mentioned objectives the methodology to be used is as follows;

- For stage 1:
    A. Identify the available rating systems on the market.

B. Choosing the rating systems in the market that are either in the region or are widely known and used.

C. Performing a comparative analysis for the chosen rating systems by cross matching similar credits in each system with the other rating systems.

D. Coming up with a final comprehensive list of categories and their sub-credits that cover all the aspects covered by all of the compared systems.

  - The outcomes of this stage are:

    - A comparison between the categories and their sub-credits of the rating systems compared along with their corresponding weights and percentage of importance and effect on the environment.

- For stage 2:

A. Developing a questionnaire from the developed comprehensive list of categories and their sub-credits.

B. Validating the questionnaire with professionals in the industry.

C. Editing the questionnaire to match their recommendations on the categories, format and credits.

D. Asking professionals in the field to comment on the importance of each credit in comparison to the others

E. Perform an AHP analysis to come up with the average weighting given by all participants in the questionnaire.

F. Compare the developed weightings with the rating systems that were compared at first to refine them.

- The outcomes of this stage are:

    - Weightings that represent the Egyptian market for the previously developed comprehensive list of credits.

CHAPTER 4

COMPARISON BETWEEN ALTERNATIVE RATING SYSTEMS

4.1 IDENTIFYING THE AVAILABLE RATING SYSTEMS ON THE MARKET

This step has been performed extensively in chapter 2.

4.2 CHOICE OF RATING SYSTEMS TO COMPARE

In order to create a rating system that suites Egypt, the first step is to compare relevant as well as known rating systems therefore four rating systems were chosen; two are foreign rating systems, one is the most recent rating system developed in the region and the last one is a foreign rating system that was adapted to the Gulf region. The rating systems chosen were:

1. **GREEN GLOBES**

   This rating system was chosen because it has an online self-assessment protocol. It is also interactive, flexible, and generates assessment and guidance reports.

2. **LEED V3 for New Construction**

   This system is one of the most popular rating systems globally –if not the most popular. It features measurable evaluation characteristics and is very practical and user-friendly, as it is available online.

   The LEED for New Construction Rating System is designed to guide and distinguish high-performance commercial and institutional projects, including

office buildings, high-rise residential buildings, government buildings, recreational facilities, manufacturing plants and laboratories.

3. ESTIDAMA buildings

This rating system was chosen as it was in Abu Dhabi –a country in the region. It is one of the most recent rating systems developed.

4. BREEAM Gulf

It is a version of the most popular European rating system, available for any country in Europe, but adapted to match the environment in the Gulf region, with measurable evaluation characteristics. It is practical to be implemented by the user.

4.3 COMPARATIVE ANALYSIS

In appendix B, you can find the comprehensive comparison between the above mentioned rating systems. The comparison was developed by grouping similar sub category side by side. Each sub category has its own credit value according to each rating system. For the sub categories, the weights shown represent their percentage from the category it is listed under in the comparison in appendix B, so the weights shown later depend mainly on the organization and cross listing choices in this thesis.

In this thesis, in the comparison shown in appendix B, Prerequisites were accounted for with a zero% weight, whereas none covered items where left blank. Also, some sub categories were covered under several credits in one

rating system while covered in one credit in the other even between several main categories and not only inside the same category itself, so the credits and weights were written only once while mentioning the that this sub category was mentioned before or will be mentioned again later.

As for the BREEAM Gulf categories credits and weights, they were developed by dividing each sub category's credit by the total credit of the category it is listed under, then it was multiplied by its category weight (the one it is listed under in the original BREEM check list) then it was multiplied once more by the total rating system's credits available to calculate each sub category's true credits independent from the original organization of the rating system categories and their sub categories. The description of the details of each sub category was edited to match the new credits. The calculation is shown below in table 7.

Table 7 - BREEAM credits calculation

	A	B	C	D	E	F	G	H
1						Percentage section credits achieved	Overall Weighted Percentage & weighted Percentage section credits	Overall Weighted credits
2	Credit Ref	Credit Title		Max credits available		116	100%	116.00
3	*Management*			23.65		100.00%	8.00%	9.28
4	Man 1	Commissioning	**Before editing** **1st credit:** Where evidence provided demonstrates that an appropriate project team member has been appointed to monitor commissioning on behalf of the client to ensure commissioning will be carried out in line with current best practice. **2nd credit:** Where evidence provided demonstrates that seasonal commissioning will be carried out during the first year of occupation, post construction (or post fit out).	2		8.46%	0.68%	0.78
5	Man 2	Considerate Constructors	**1st Credit:** Where evidence provided demonstrates that there is a commitment to comply with best practice site management principles. **2nd Credit:** Where evidence provided demonstrates that there is a commitment to go beyond best practice site management principles.	2		8.46%	0.68%	0.78
						Calculation used		
	Management			9.28		100.00%	8.00%	K3*116
3	Man 1	Commissioning	**After editing** **1st half:** Where evidence provided demonstrates that an appropriate project team member has been appointed to monitor commissioning on behalf of the client to ensure commissioning will be carried out in line with current best practice. **2nd half:** Where evidence provided demonstrates that seasonal commissioning will be carried out during the first year of occupation, post construction (or post fit out).	1.69		D4/D3	F4*G3	G4*116
4	Man 2	Considerate Constructors	**1st half:** Where evidence provided demonstrates that there is a commitment to comply with best practice site management principles. **2nd half:** Where evidence provided demonstrates that there is a commitment to go beyond best practice site management principles.	1.69		D5/D3	F5*G3	G5*116

- Main Categories

From the comparison shown in appendix B, a list of main categories and their total credits and corresponding weights was developed. The total number of credits in each main category is the sum of all the credits given to all items listed under that category. Then the total credits value for each main category was divided by the total credits available in that particular rating system to calculate the corresponding weight for that main category. The same is done for the sub-items inside each main category, where the weights here are calculated in correspondence to the total credits of the main category –not the total credits of the rating system itself. This was done to ease the comparison between the rating systems. In table 8 a snap shot of the total credits and their corresponding weights for each main category of the four rating systems compared, then in figures 12 and 13 the Main credits weights comparison is further illustrated.

It can be observed from those illustrations shown below, that both Green Globes and LEED are biased towards energy use with a much lower weight for water use. While in ESTIDAMA Both energy as well as water use are of nearly equal importance with the energy use having a slightly higher weight and all the rest categories nearly having little difference in weighting. On the other hand BREEAM Gulf views water use to be of much higher value than energy use.

Also, it can be noticed that BREEAM gives the highest weight among rating systems to pollution as well as the least weigh among them for livable outdoors and transportation. While LEED does exactly the opposite of BREEAM in regards of these two main categories' weights. Green globes on the other hand gives low weight

for pollution and livable outdoors and transportation while gives the highest weight among the rating systems compared for indoor environmental quality. Material credits on the other hand is nearly equally weighted among the compared rating system as well as site ecology.

Surprisingly enough the other sustainable systems and processes has the highest and lowest weights in LEED and Green Globes respectively which are both applied in the US. Green Globes rates energy use the highest followed by indoor environmental quality with the rest categories nearly equally rated. While LEED views energy use as the sole most important category with all the rest categories nearly equal except for pollution as the least important category. In BREEAM Gulf water is the most important followed by energy and indoor environmental quality then pollution then site ecology followed by the other sustainable systems and processes then last comes the livable outdoors and transportation.

In the spider chart in figure 12, it can be noticed that most of the rating systems are in the same region for all the main categories except for a large gap in water use between ESTIDAMA and BREEAM Gulf if compared to the other two rating systems. This makes sense because those two systems are for the Middle East where water is scarce and valuable due to the limitation of its sources.

Table 8 – Main categories weights comparison between Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF

Green Globes V.0	**1000**	**100%**		**LEED V3-NC**	**110**	**100%**		**ESTIDAMA Buildings**	**179.0**	**100%**		**BREEAM Gulf**	**116.0**	**100%**
Energy use	300.0	30.00%		Energy and Atmosphere	31.0	28.18%		Resourceful Energy	41.0	22.91%		Energy	17.47	15.06 %
Water Use	85.0	8.50%		Water Efficiency	10.0	9.09%		Precious Water	39.0	21.79%		Water credits	31.62	27.26 %
Pollution (emission, solid waste, effluents)	90.0	9.00%			6.0	5.45%		Stewarding Materials	14.0	7.82%		Pollution credits	14.64	12.62 %
Material/Product Inputs	90.0	9.00%		Materials and Resources	12.0	10.91%		Stewarding Materials	22.0	12.29%		Materials credits	11.08	9.55%
Indoor air quality & occupant comfort	200.0	20.00%		Indoor Environmental Quality	14.0	12.73%		Livable Buildings : Indoors	20.0	11.17%		Health and Wellbeing	16.11	13.89 %
Transport	80.0	8.00%		Sustainable Sites	12.0	10.91%		Livable Buildings : Outdoors	11.0	6.15%		Transport credits	3.00	2.59%
Site ecology	115.0	11.50%		Sustainable Sites	13.0	11.82%		Natural Systems	16.0	8.94%		Land Use and Ecology Credits	12.68	10.93 %
Other sustainable systems & processes	40.0	4.00%		Innovation and Design Process	12	10.91%		Integrated Development Process	16	8.94%		Management	6.75	5.82%

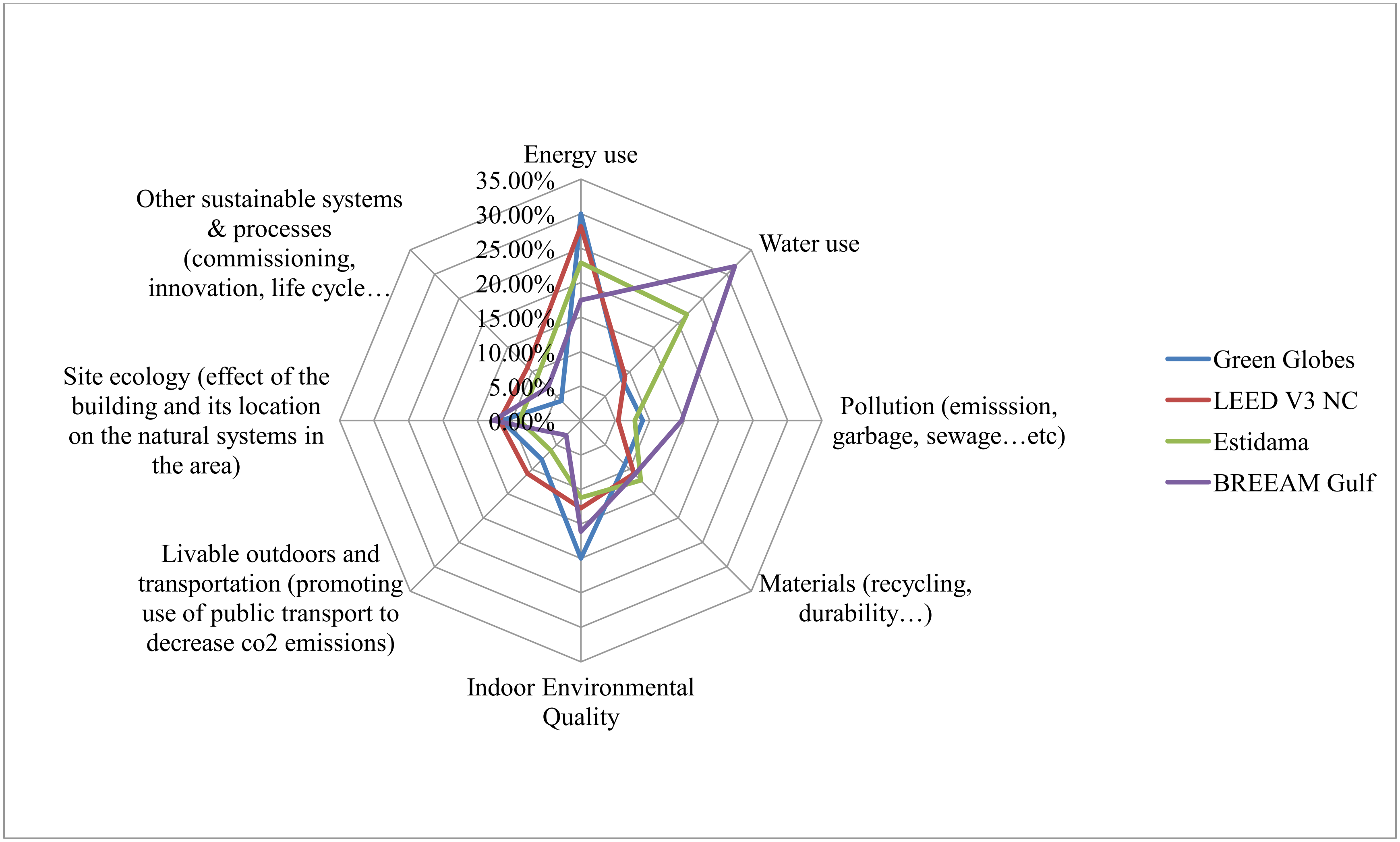
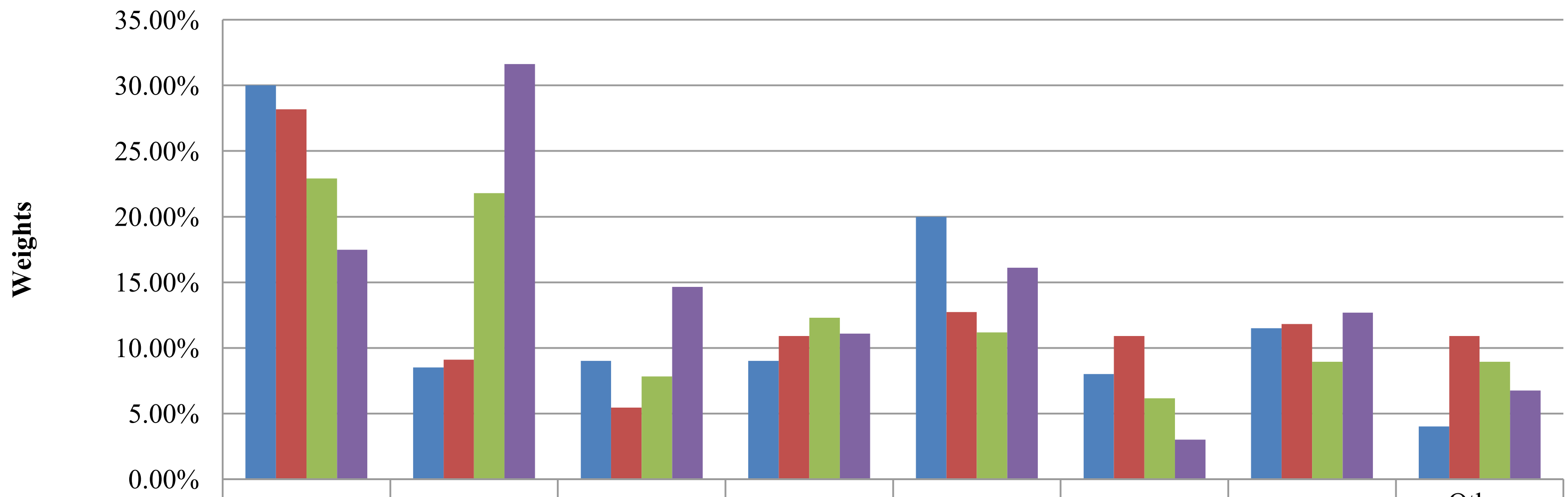


Figure 12 - Spider chart for main Categories weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF



	Energy use	Water use	Pollution (emisssion, garbage, sewage…etc)	Materials (recycling, durability…)	Indoor Environment al Quality	Livable outdoors and transportatio n (promoting use of public transport to decrease co2 emissions)	Site ecology (effect of the building and its location on the natural systems in the area)	Other sustainable systems & processes (commission ing, innovation, life cycle costing…)
Green Globes	30.00%	8.50%	9.00%	9.00%	20.00%	8.00%	11.50%	4.00%
LEED V3 NC	28.18%	9.09%	5.45%	10.91%	12.73%	10.91%	11.82%	10.91%
Estidama	22.91%	21.79%	7.82%	12.29%	11.17%	6.15%	8.94%	8.94%
BREEAM Gulf	17.47%	31.62%	14.64%	11.08%	16.11%	3.00%	12.68%	6.75%

Figure 13 - Graphical presentation for main categories weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF

1. Energy use

In figures 14 and 15, Both LEED and ESTIDAMA viewed abiding with minimum energy performance standard levels as a prerequisite for any building that seeks green label, but they disagree later on upon whether other items should be prerequisites or not. For example, LEED views reduced energy demand as well as integration of energy efficient appliances as prerequisites. Whereas, ESTIDAMA sees that energy monitoring is the sub category that needs to be a prerequisite. BREEAM Gulf gives both a weight as well as a required minimum credits to earn for each certification level sought. So, it gives a high rate for abiding with performance standards in the area of CO_2 emissions reduction, sub metering and low or zero carbon technologies. LEED gives its highest weight in this area for improved energy performance.

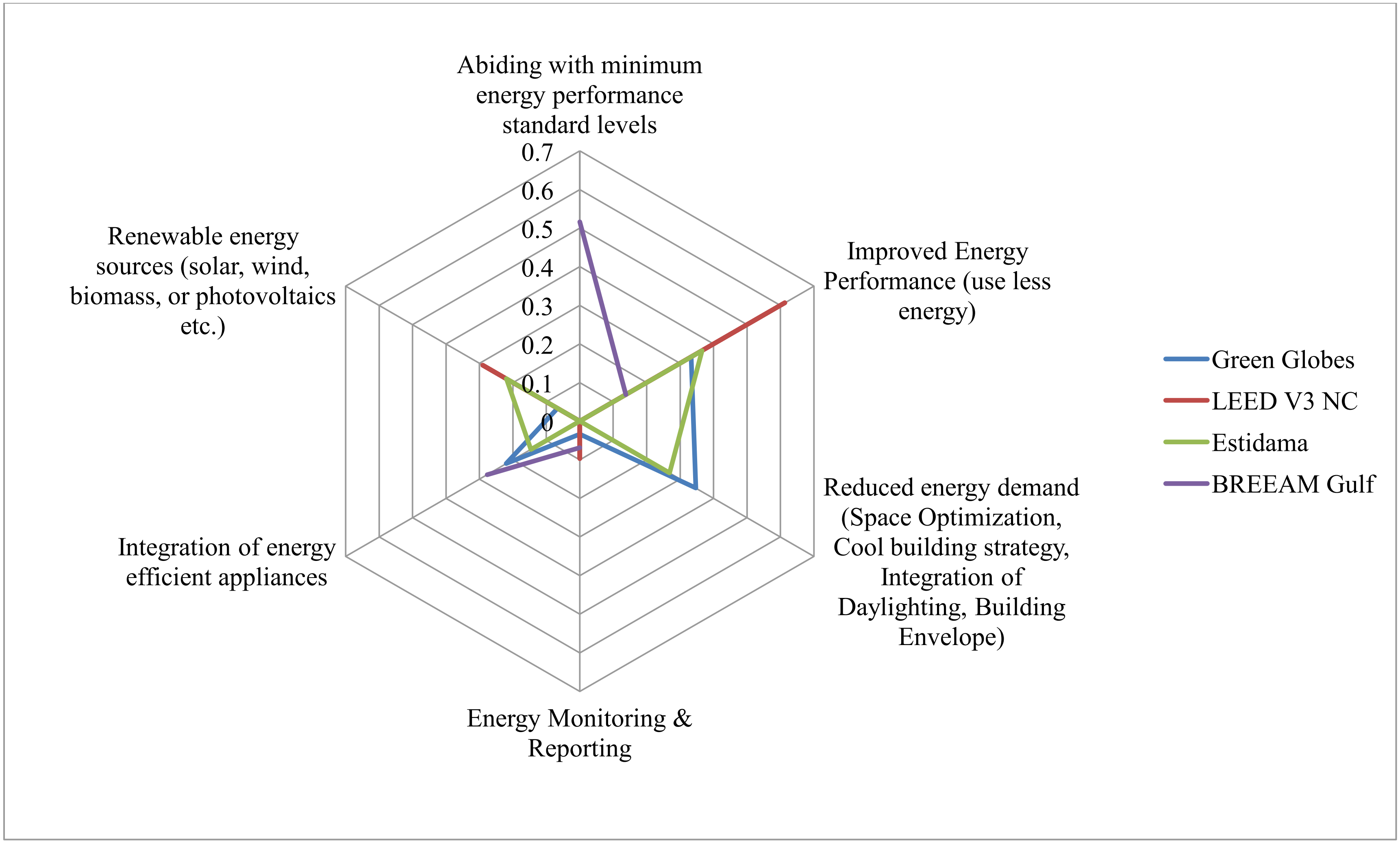
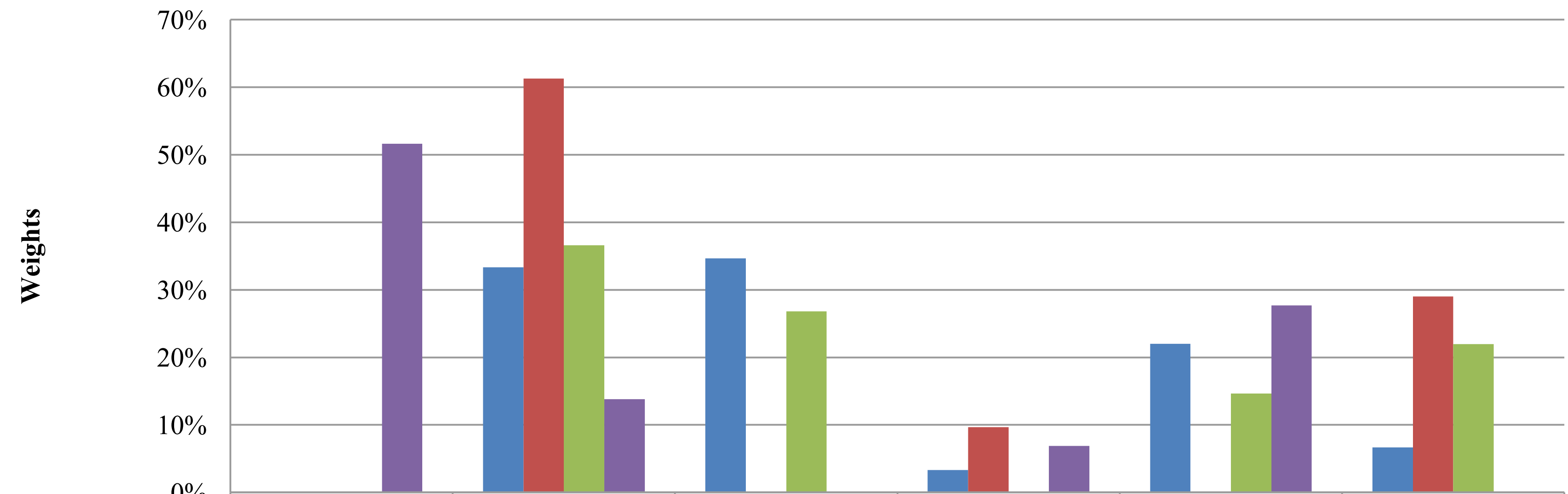


Figure 14 - Spider chart for energy use weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF



	Abiding with minimum energy performance standard levels	Improved Energy Performance (use less energy)	Reduced energy demand (Space Optimization, Cool building strategy, Integration of Daylighting, Building Envelope)	Energy Monitoring & Reporting	Integration of energy efficient appliances	Renewable energy sources (solar, wind, biomass, or photovoltaics etc.)
Green Globes		33.33%	34.6667%	3.33%	22.00%	6.67%
LEED V3 NC	0.00%	61.29%	0.00%	9.68%	0.00%	29.03%
Estidama	0.00%	36.59%	26.83%	0.00%	14.63%	21.95%
BREEAM Gulf	51.63%	13.80%		6.87%	27.70%	

Figure 15 - Graphical presentation for energy use weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF

2. Water use

From figure 16 and 17, it can be noticed that BREEAM doesn’t address minimizing water use reduction, yet gives 50% on water efficient equipment. LEED and Green Globes on the other hand have the later as a prerequisite. LEED gives each of minimizing water use as well as minimizing water use in cooling towers a high 40% for each, yet doesn’t address the other aspects. ESTIDAMA gives 30% on water efficient irrigation systems and 20.5% on water efficient plants, which is understandable considering their climate and water resources. BREEAM Gulf gives 30% for grey water techniques while Green Globes gives it 11.7% and the other two systems don’t address this issue.

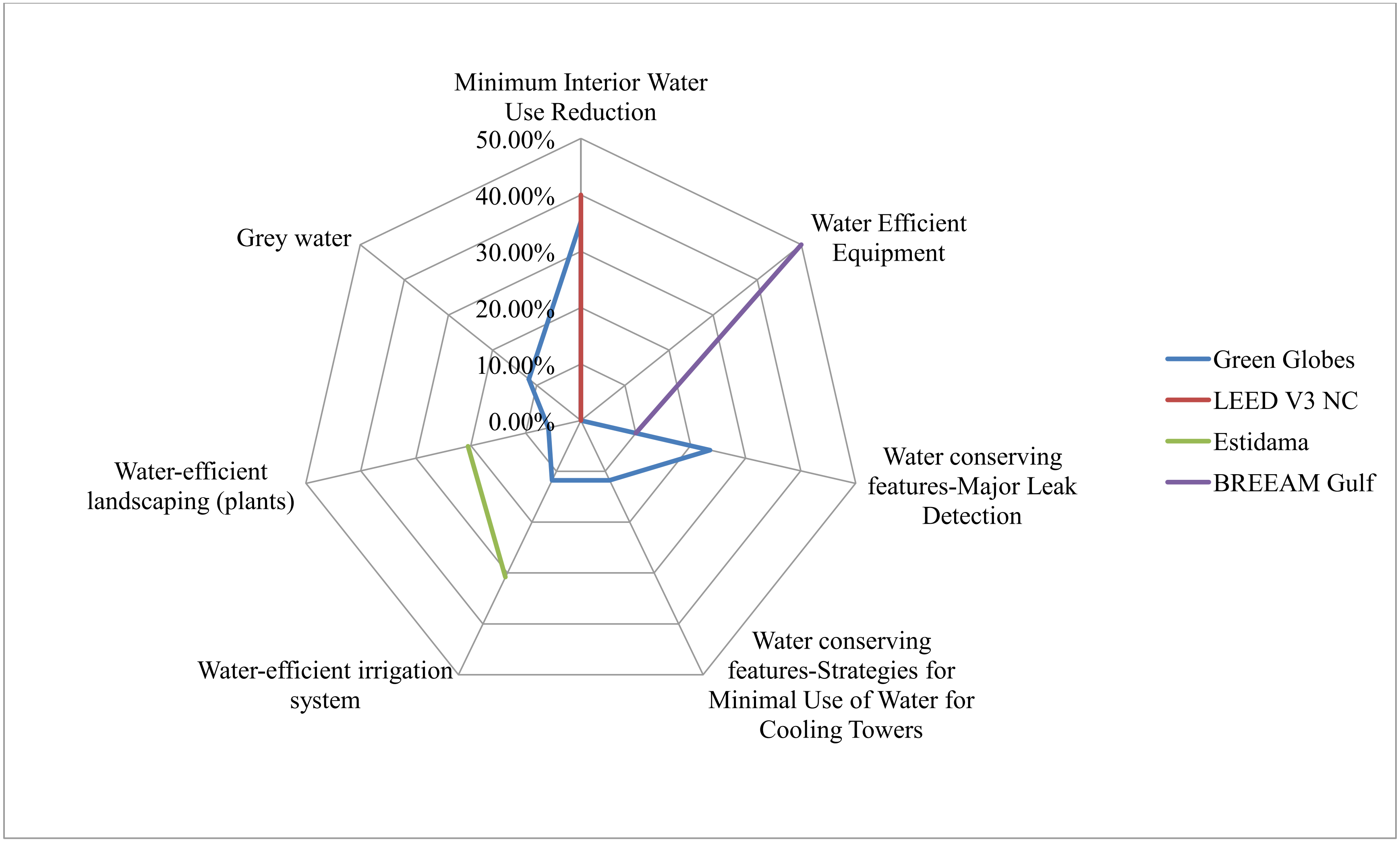
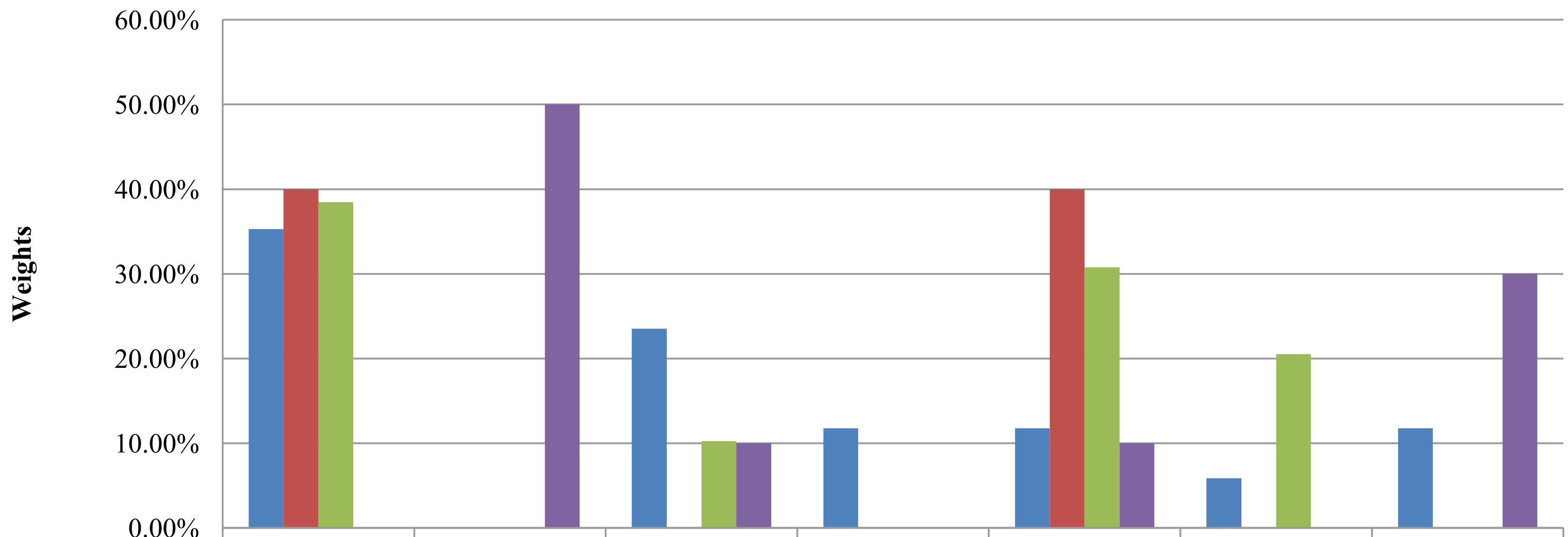


Figure 16 - Spider chart for water use weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF



	Minimum Interior Water Use Reduction	Water Efficient Equipment	Water conserving features-Major Leak Detection	Water conserving features-Strategies for Minimal Use of Water for Cooling Towers	Water-efficient irrigation system	Water-efficient landscaping (plants)	Grey water
Green Globes	35.29%	0.00%	23.53%	11.76%	11.76%	5.88%	11.76%
LEED V3 NC	40.00%	0.00%			40.00%		
Estidama	38.46%		10.26%		30.77%	20.51%	
BREEAM Gulf		50.00%	9.99%		9.99%		30.01%

Figure 17 - Graphical presentation for water use weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF

3. Pollution

In figure 18 and 19, the highest weight for air pollution is in Green Globes for 44%. LEED views operational waste management as a prerequisite, while gives 33% to air pollution as well as construction waste management. ESTIDAMA gives equal weights of 28.6 for both water and air pollution, while BREEM Gulf gives equal weights of 37% for water pollution as well as hazardous material management.

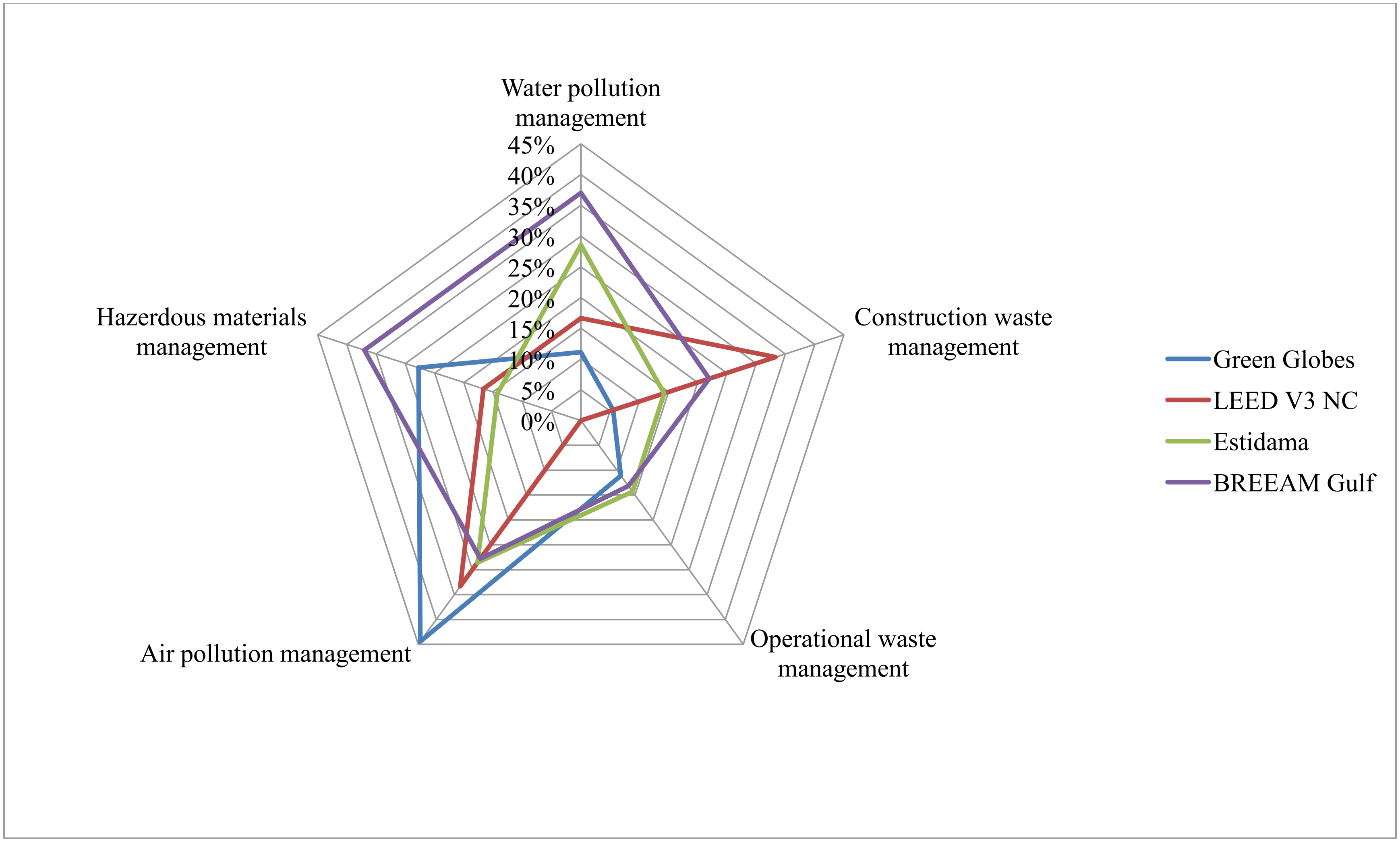
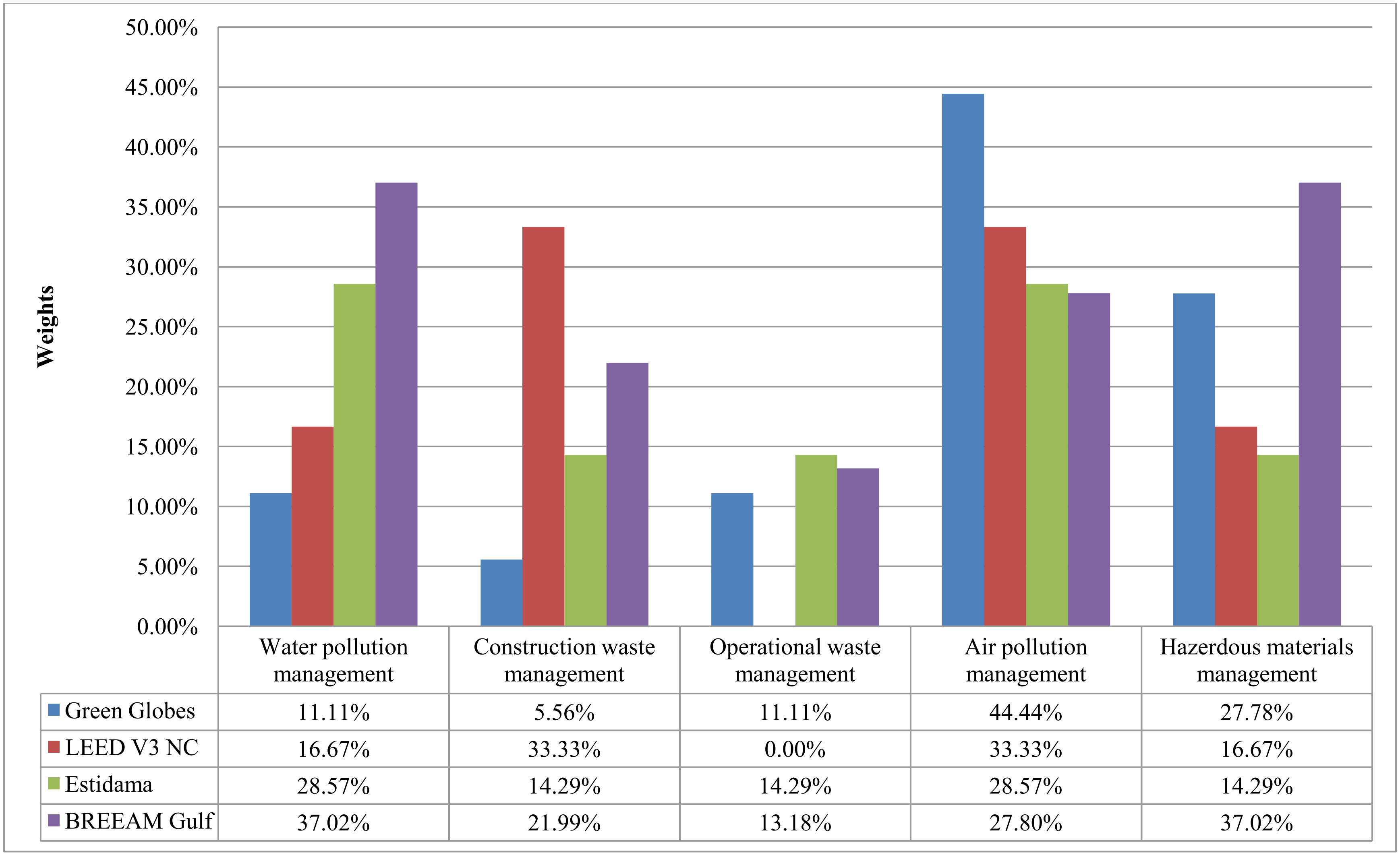


Figure 18 - Spider chart for pollution weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF



	Water pollution management	Construction waste management	Operational waste management	Air pollution management	Hazerdous materials management
Green Globes	11.11%	5.56%	11.11%	44.44%	27.78%
LEED V3 NC	16.67%	33.33%	0.00%	33.33%	16.67%
Estidama	28.57%	14.29%	14.29%	28.57%	14.29%
BREEAM Gulf	37.02%	21.99%	13.18%	27.80%	37.02%

Figure 19 - Graphical presentation for pollution weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF

4. Materials

In figure 20 and 21, BREEM Gulf doesn't address recycled materials or rapidly renewable materials or regional materials. LEED doesn't consider durability, flexibility, adaptability and disassembly, while reviews energy efficient materials and low impact materials as prerequisites. The highest score in LEED in this sub category is for building reuse of 33% while for ESTIDAMA the highest weight is for recycled materials for 27%. Green Globes gives its highest score to low impact materials for 39%.

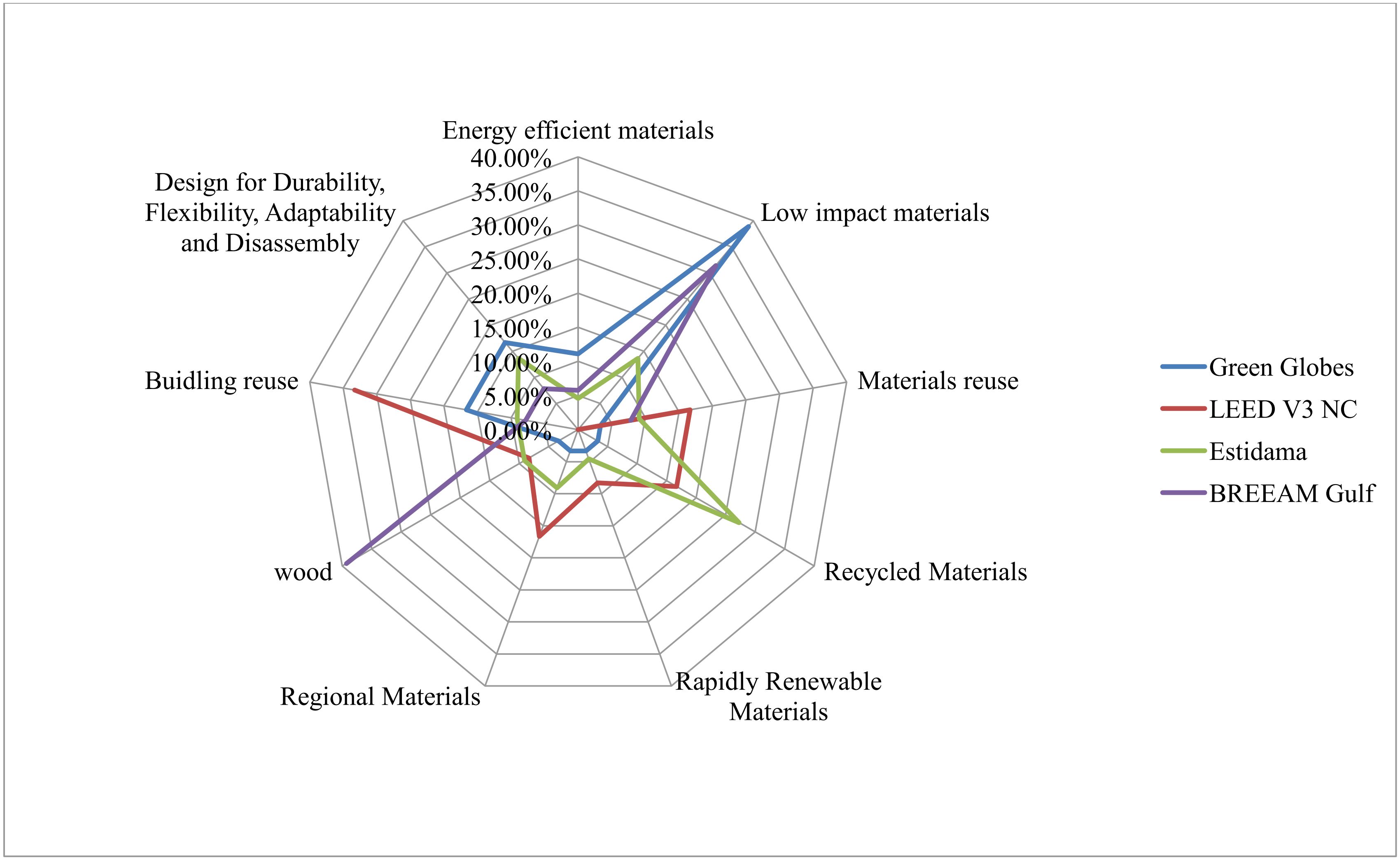
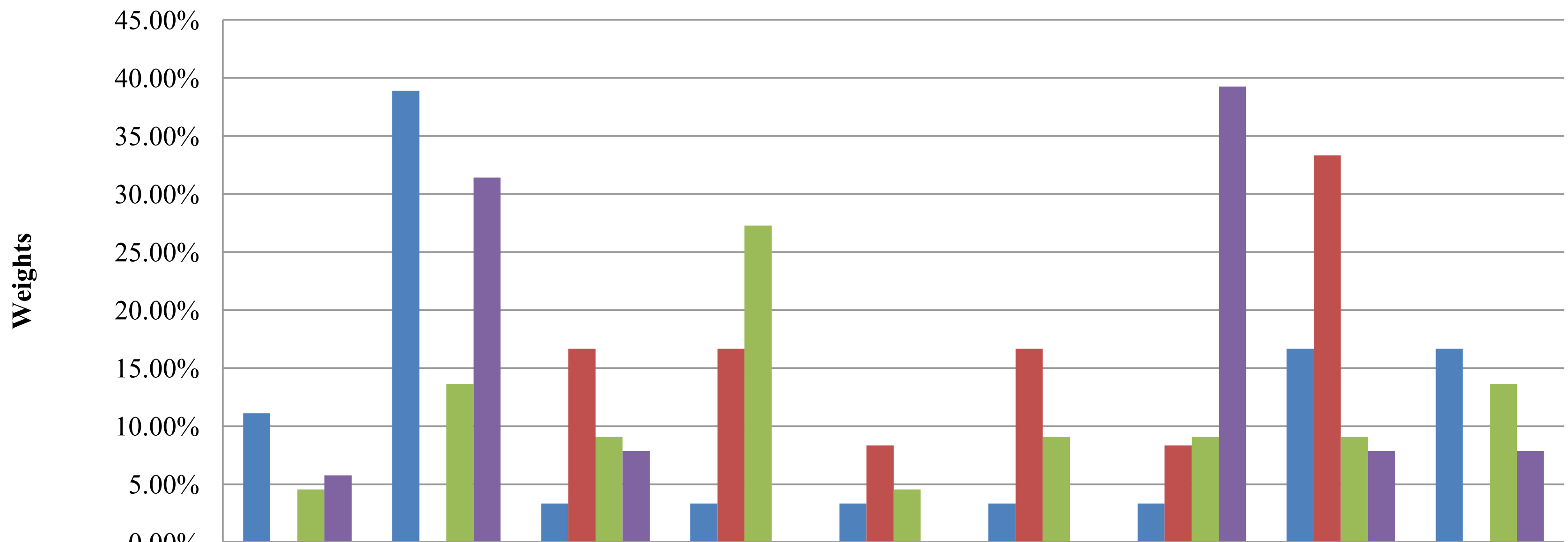


Figure 20 - Spider chart for material weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF



	Energy efficient materials	Low impact materials	Materials reuse	Recycled Materials	Rapidly Renewable Materials	Regional Materials	wood	Buidling reuse	Design for Durability, Flexibility, Adaptability and Disassembly
Green Globes	11.11%	38.89%	3.33%	3.33%	3.33%	3.33%	3.33%	16.67%	16.67%
LEED V3 NC	0.00%	0.00%	16.67%	16.67%	8.33%	16.67%	8.33%	33.33%	
Estidama	4.55%	13.64%	9.09%	27.27%	4.55%	9.09%	9.09%	9.09%	13.64%
BREEAM Gulf	5.78%	31.41%	7.85%				39.26%	7.85%	7.85%

Figure 21 - Graphical presentation for material weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF

5. Indoor environmental quality

In figure 22 and 23, construction indoor air quality is not covered by both Green Globes and BREEAM Gulf. While acoustic comfort is not addressed by LEED. Also, smoking control is not covered by Green Globes, which gives on the other hand equal scores of 25% for both ventilation and lighting quality, also ESTIDAMA rates them equally by giving them 20%. Minimum indoor air quality is a prerequisite under LEED and ESTIDAMA.

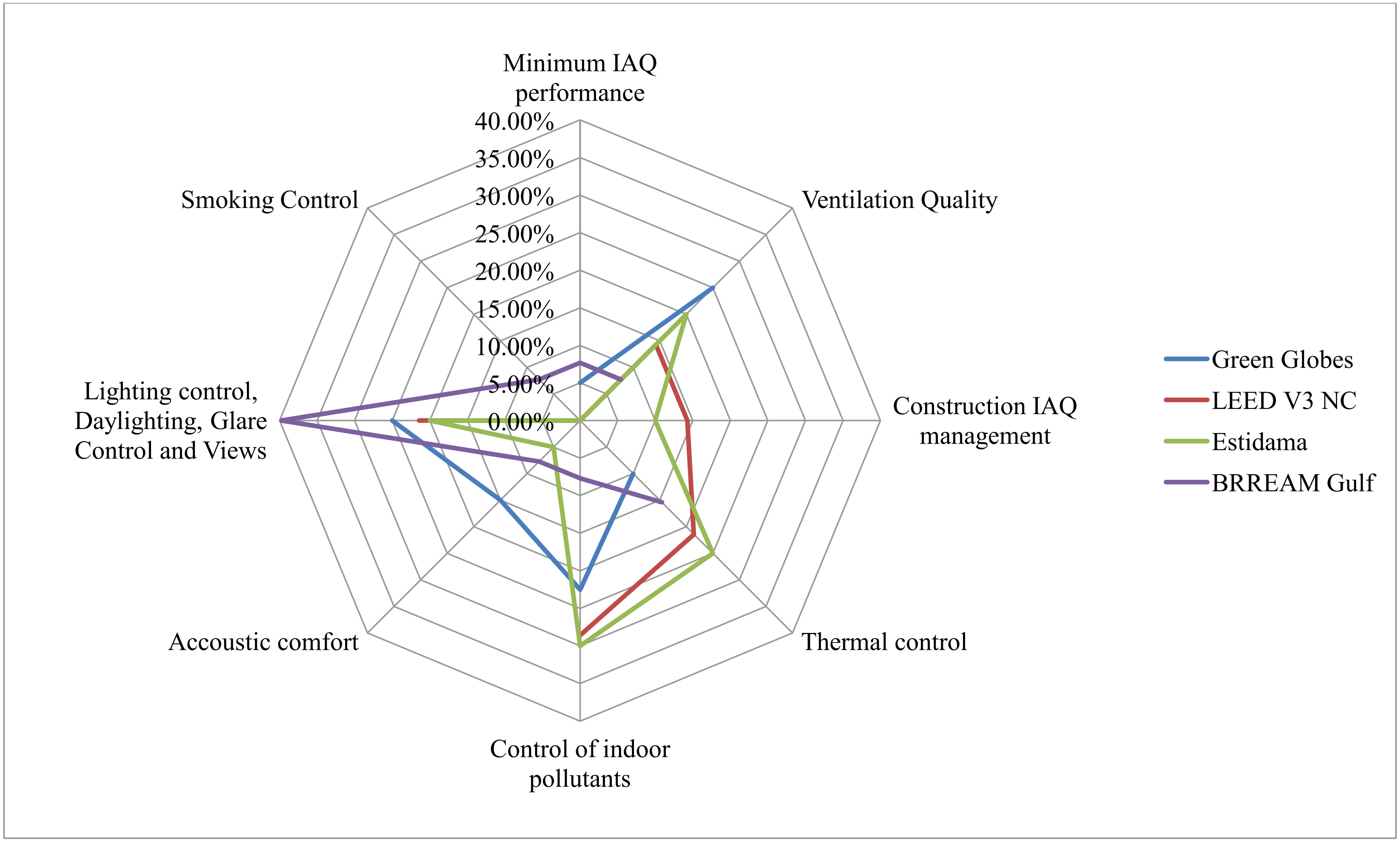
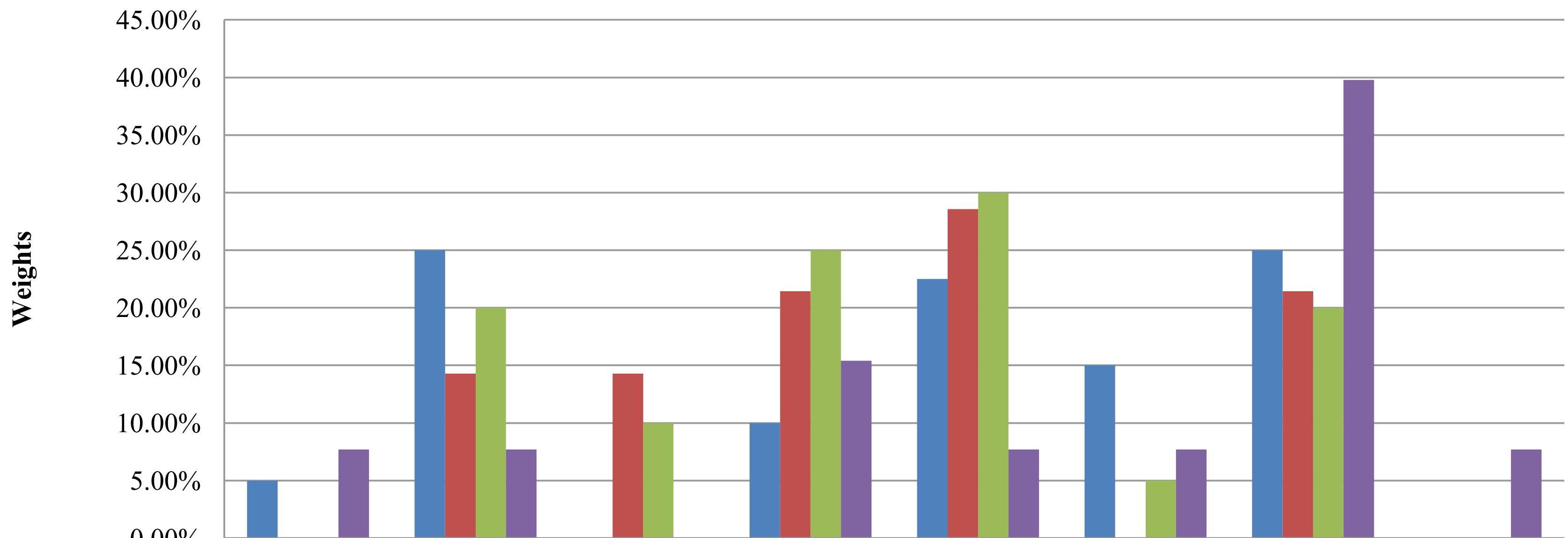


Figure 22 - Spider chart for indoor environmental quality weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF



	Minimum IAQ performance	Ventilation Quality	Construction IAQ management	Thermal control	Control of indoor pollutants	Accoustic comfort	Lighting control, Daylighting, Glare Control and Views	Smoking Control
Green Globes	5.00%	25.00%		10.00%	22.50%	15.00%	25.00%	
LEED V3 NC	0.00%	14.29%	14.29%	21.43%	28.57%		21.43%	0.00%
Estidama	0.00%	20.00%	10.00%	25.00%	30.00%	5.00%	20.00%	0.00%
BRREAM Gulf	7.70%	7.70%		15.39%	7.70%	7.70%	39.79%	7.70%

Figure 23 - Graphical presentation for indoor environmental quality weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF

6. Livable outdoors and transportation

In figure 24 and 25, it can be noticed that both Green Globes and LEED ignore all items except for energy efficient transportation. Only BREEM Gulf considers pedestrian safety, yet ignores outdoor thermal comfort as well as active urban environments.

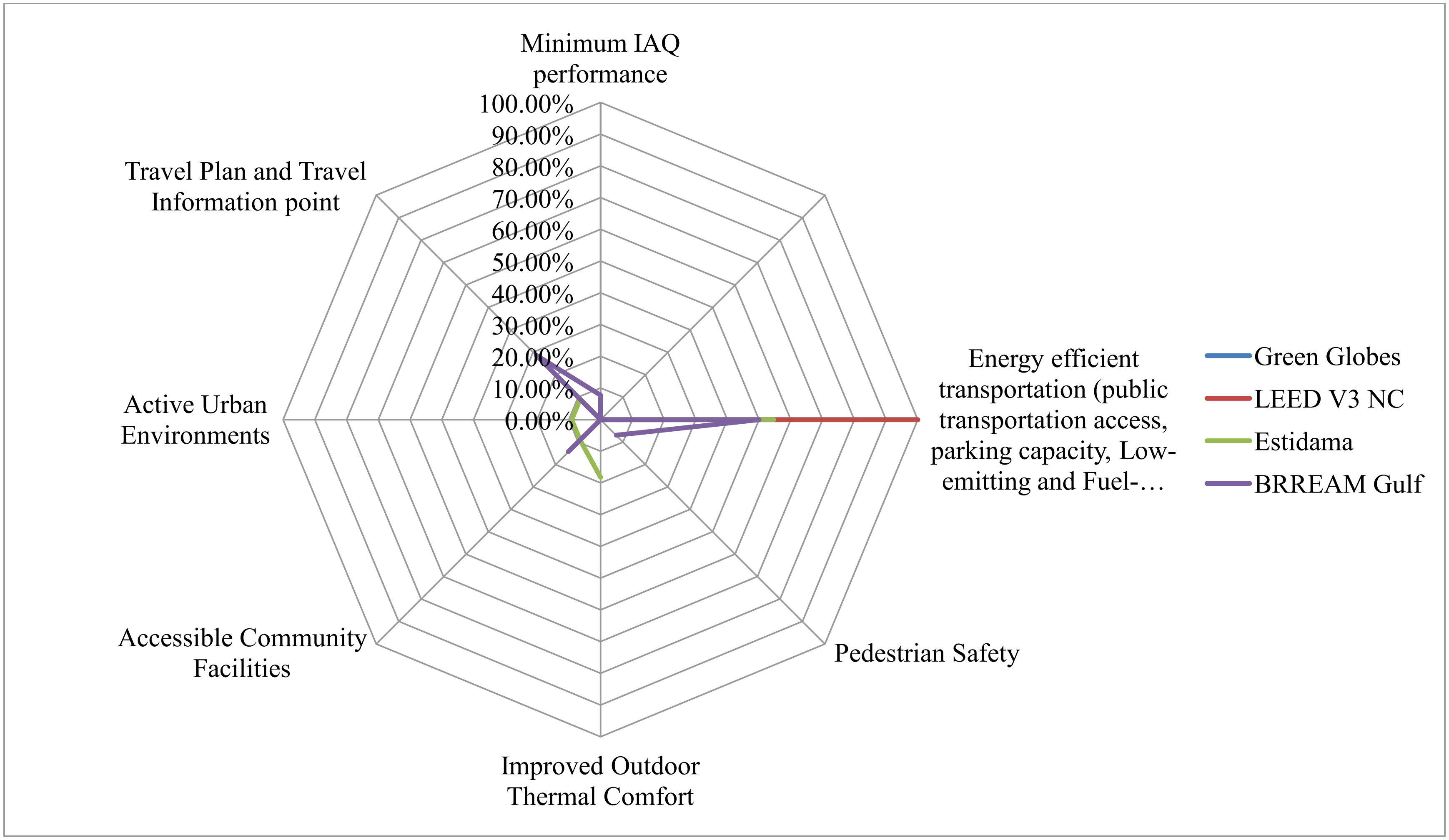
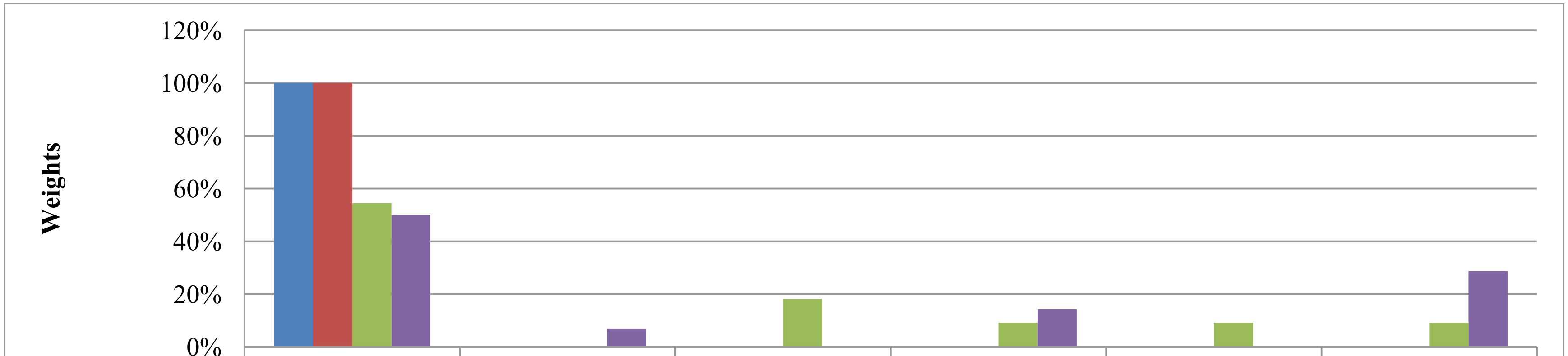


Figure 24 - Spider chart for livable outdoors and transportation weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF



	Energy efficient transportation (public transportation access, parking capacity, Low-emitting and Fuel-efficient Vehicles and bicycle, storage & changing rooms)	Pedestrian Safety	Improved Outdoor Thermal Comfort	Accessible Community Facilities	Active Urban Environments	Travel Plan and Travel Information point
Green Globes	100.00%					
LEED V3 NC	100.00%					
Estidama	54.55%		18.18%	9.09%	9.09%	9.09%
BREEAM Gulf	50.00%	7.00%		14.33%		28.67%

Figure 25 - Graphical presentation for livable outdoors and transportation weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF

7. Site ecology

In figure 26 and 27, it can be noticed that the highest score for site selection is by LEED, while the highest score for natural systems protection is by BREEM Gulf. Green Globes and ESTIDAMA give high rate for reuse of land.

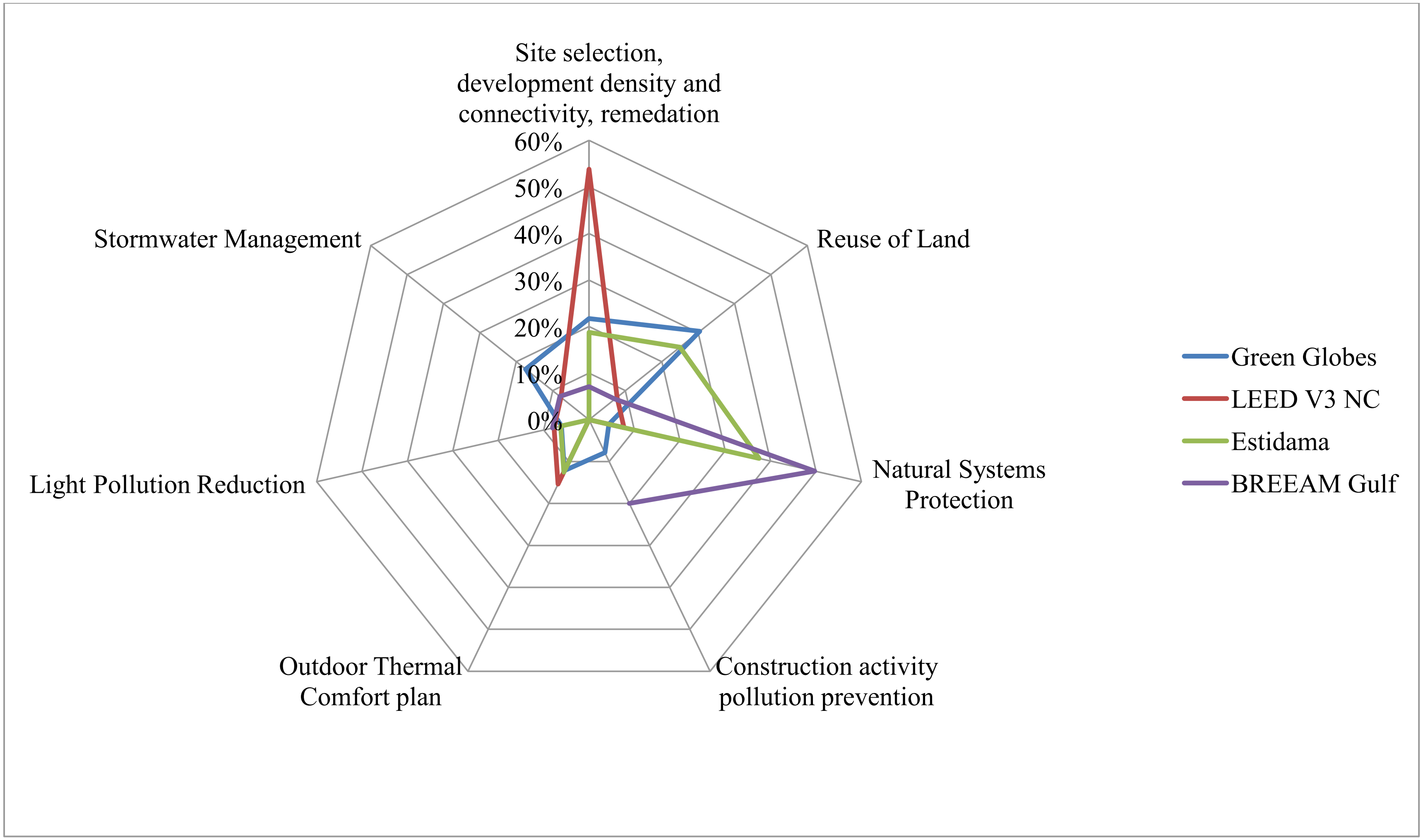
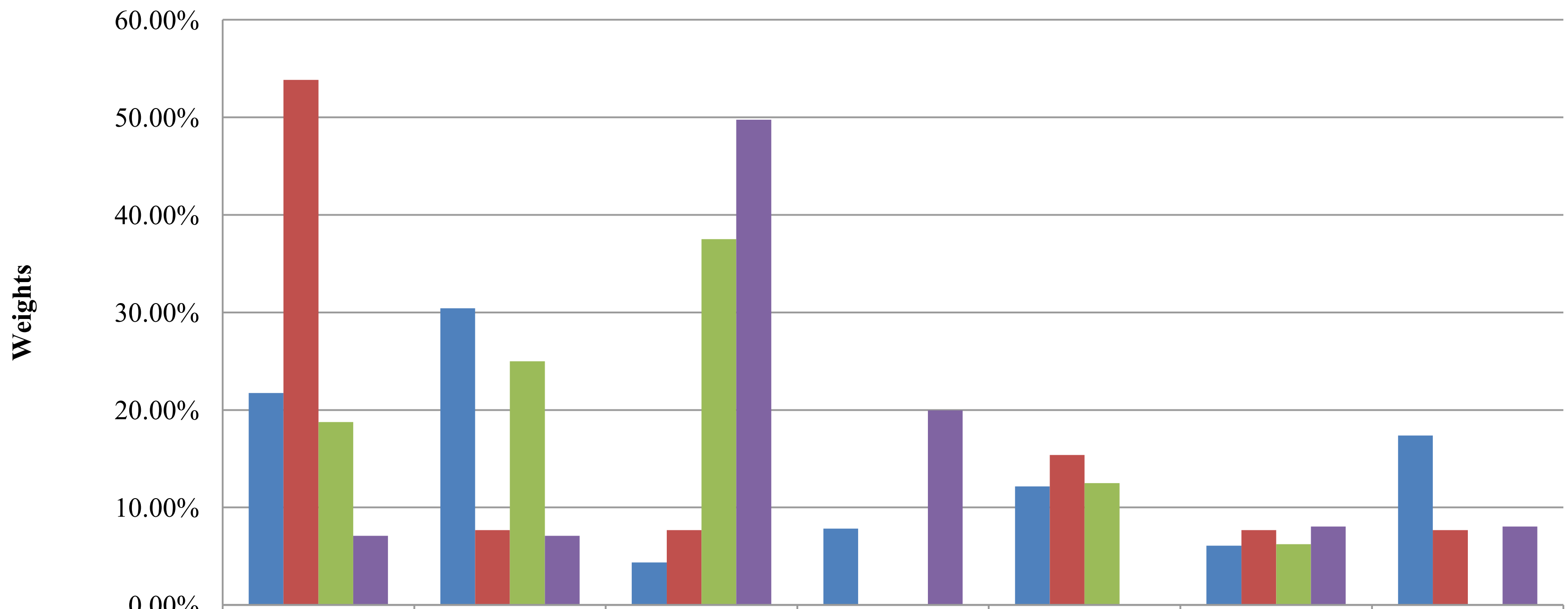


Figure 26 – Spider chart for Site ecology weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF



	Site selection, development density and connectivity, remedation	Reuse of Land	Natural Systems Protection	Construction activity pollution prevention	Outdoor Thermal Comfort plan	Light Pollution Reduction	Stormwater Management
Green Globes	21.74%	30.43%	4.35%	7.83%	12.17%	6.09%	17.39%
LEED V3 NC	53.85%	7.69%	7.69%	0.00%	15.38%	7.69%	7.69%
Estidama	18.75%	25.00%	37.50%	0.00%	12.50%	6.25%	0.00%
BREEAM Gulf	7.10%	7.10%	49.76%	19.95%		8.04%	8.04%

Figure 27 - Graphical presentation for site ecology weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF

8. Other sustainable systems and processes

In figure 28 and 29, it is noticed that only LEED requires an accredited professional. Green Globes gives 50% of this category's weight to integrated development strategy. ESTIDAMA views this item as well as tenant fit out as prerequisites. Only BREEAM and ESTIDAMA consider life cycle costing for 25% both.

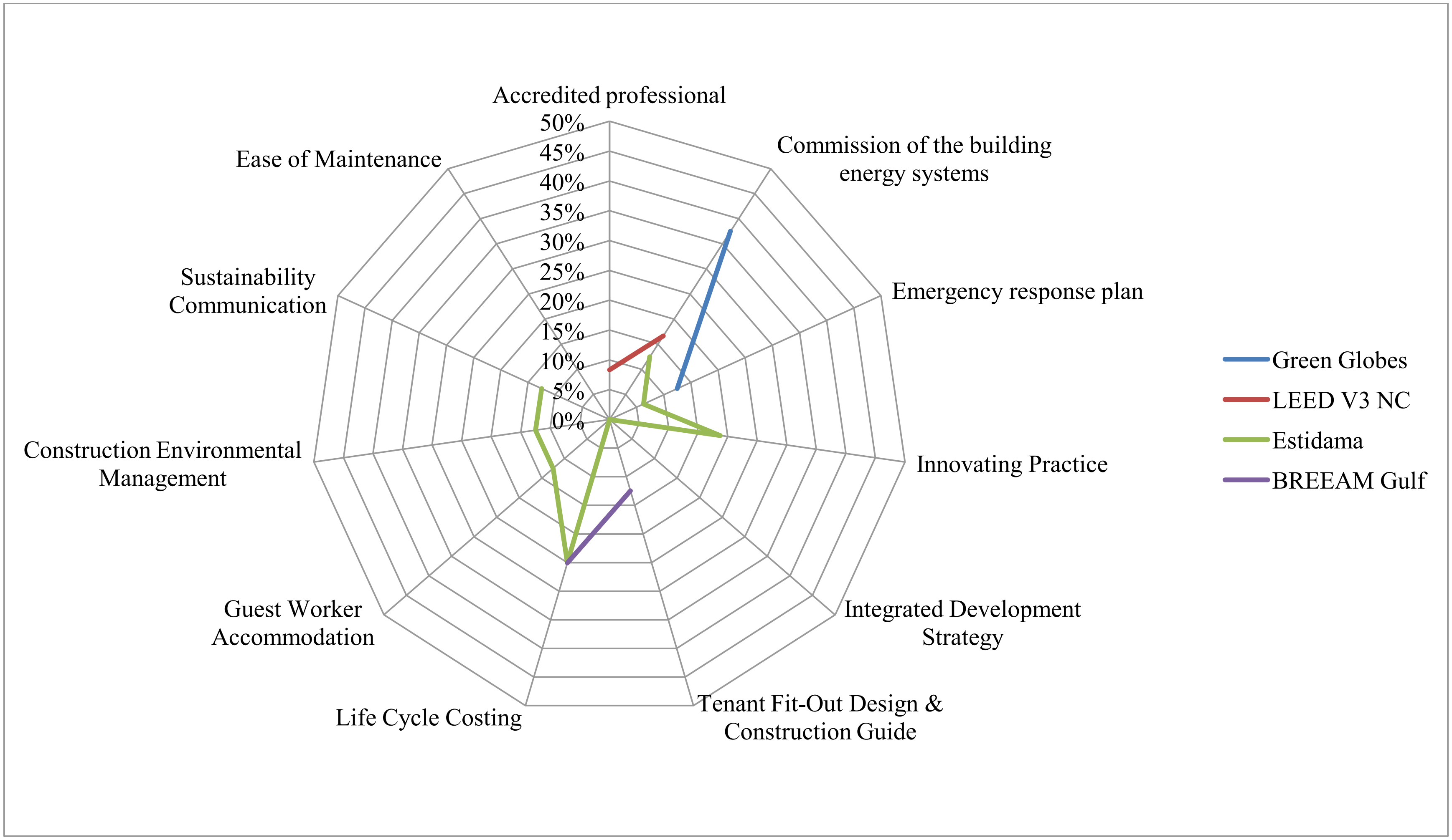
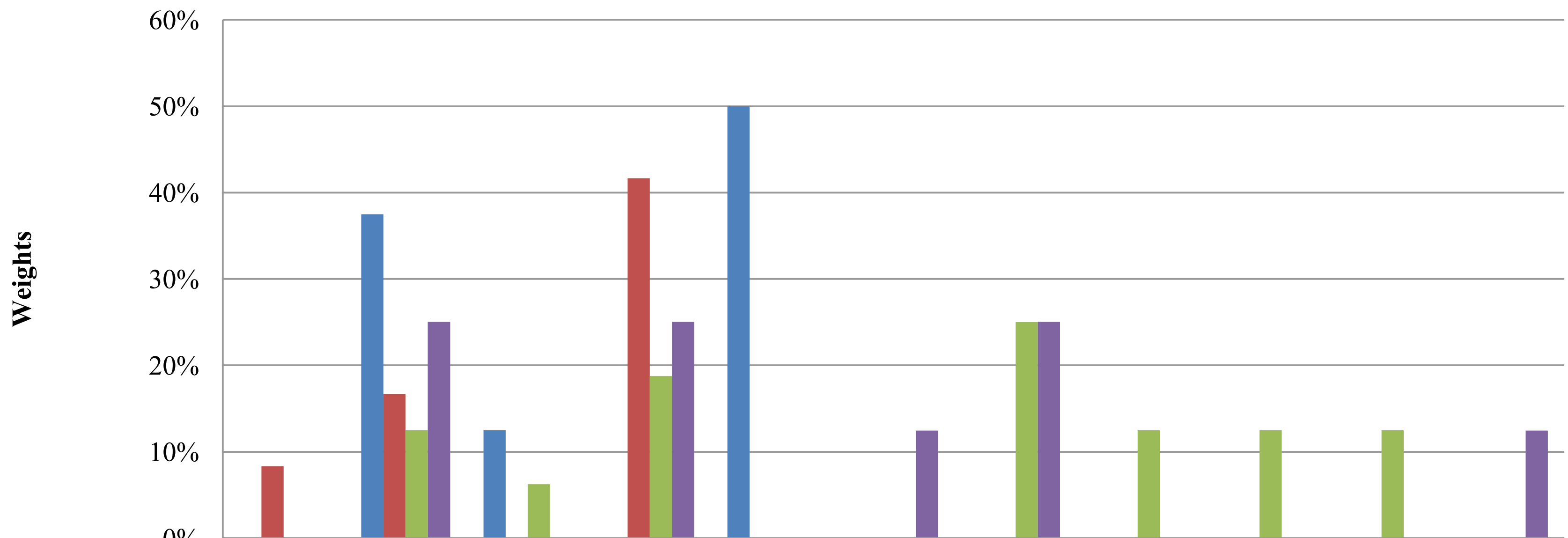


Figure 28 - Spider chart for the other sustainable systems & processes weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF



	Accredited professional	Commission of the building energy systems	Emergency response plan	Innovating Practice	Integrated Development Strategy	Tenant Fit-Out Design & Construction Guide	Life Cycle Costing	Guest Worker Accommodation	Construction Environmental Management	Sustainability Communication	Ease of Maintenance
Green Globes		37.50%	12.50%		50.00%						
LEED V3 NC	8.33%	16.67%		41.67%							
Estidama		12.50%	6.25%	18.75%	0.00%	0.00%	25.00%	12.50%	12.50%	12.50%	
BREEAM Gulf		25.04%		25.04%		12.44%	25.04%				12.44%

Figure 29 – Graphical presentation for the other sustainable systems & processes weights of Green Globes, LEED V3 NC, ESTIDAMA and BREEAM GULF

CHAPTER 5

QUESTIONNAIRE'S DESIGN AND AHP ANALYSIS

5.1 QUESTIONNAIRE'S DESIGN

As previously mentioned in the methodology in chapter 3, it was planned to perform an AHP analysis for the answers of the questionnaire. So, the questionnaire had to be formatted in a way that helps to move to the next step with no further transformations for the questionnaire's answer; thus came the matrix table format.

The questionnaire followed the same hierarchy and arrangement as the comparison table, giving nine main categories that cover all the aspects of green buildings. This has been modified later to be eight main categories by moving the "regional priority" category to be part of the "Other sustainable systems & processes" for ease.

The main categories that affect the performance of green buildings were developed to be:

1. Energy use
2. Water use
3. Pollution (emissions, garbage, sewage…etc.)
4. Materials (recycling, durability…)
5. Indoor Environmental Quality
6. Livable outdoors and transportation promoting use of public transport to decrease CO_2 emissions)

7. Site ecology (effect of the building and its location on the natural systems in the area)
8. Other sustainable systems & processes (commissioning, innovation, life cycle costing…)

5.2 CRITERIA FOR CHOOSING PEOPLE TO VALIDATE AND FILL THE QUESTIONNAIRE

In order to get answers that represent the green buildings market in Egypt, The following criteria for choosing people to validate and - later on – fill the questionnaire were followed:

- Having a background on green buildings concept and on rating systems
- Interested in having a green building rating system for Egypt
- Uses or wants to use green building rating systems in his work
- Professional working in the Egyptian market
- A plus would be being an accredited professional by any of the rating systems compared such as LEED

To validate the questionnaire, accredited professionals were asked to review it and send comments on it. These professionals are LEED accredited and have an extensive knowledge on the market and green buildings. Most communications were done through the internet with some meetings to discuss the questionnaire's format and content.

The professionals who participated in the questionnaire were two groups; the first was participants in a professional course that was given in the American University in Cairo about green buildings as an extension to previous courses on the environmental

issues upon their request. They needed to know more on green buildings as it was needed by their jobs. They worked in different companies and different disciplines. They were asked to fill the final edition of the questionnaire at the end of the course. The other group was a list of employees in a reputable company in Egypt. The second group members were all LEED accredited thus met all the above mentioned criteria.

The questionnaire was filled by an array of professionals from different disciplines covering a large range of the market. As shown in the following figure 30, there were 7 architects, 1 electric engineer, 1 operations senior manager, 1 environmental engineer, 1 urban and landscape designer, 2 mechanical engineers, 1 green buildings consultant and 1 QSHE superior. In figure 31, the number of accredited professionals versus none accredited is shown from the total 15 participants. Then in figure 32, the companies in which participants work are shown.

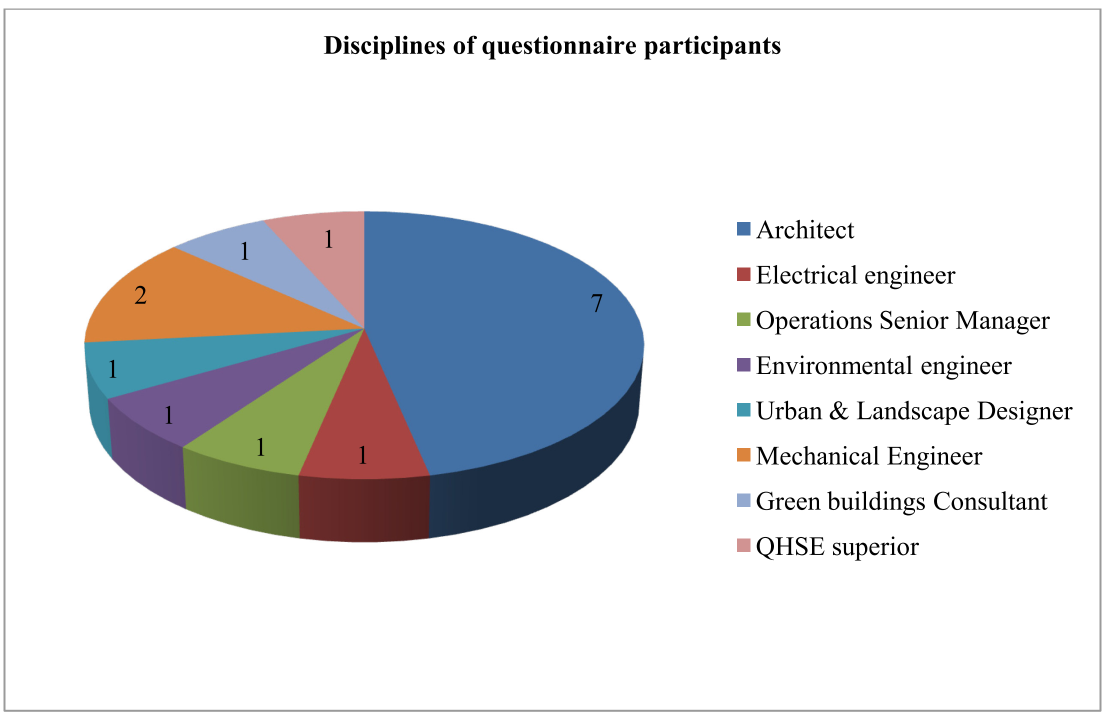


Figure 30 - Disciplines of questionnaire participants

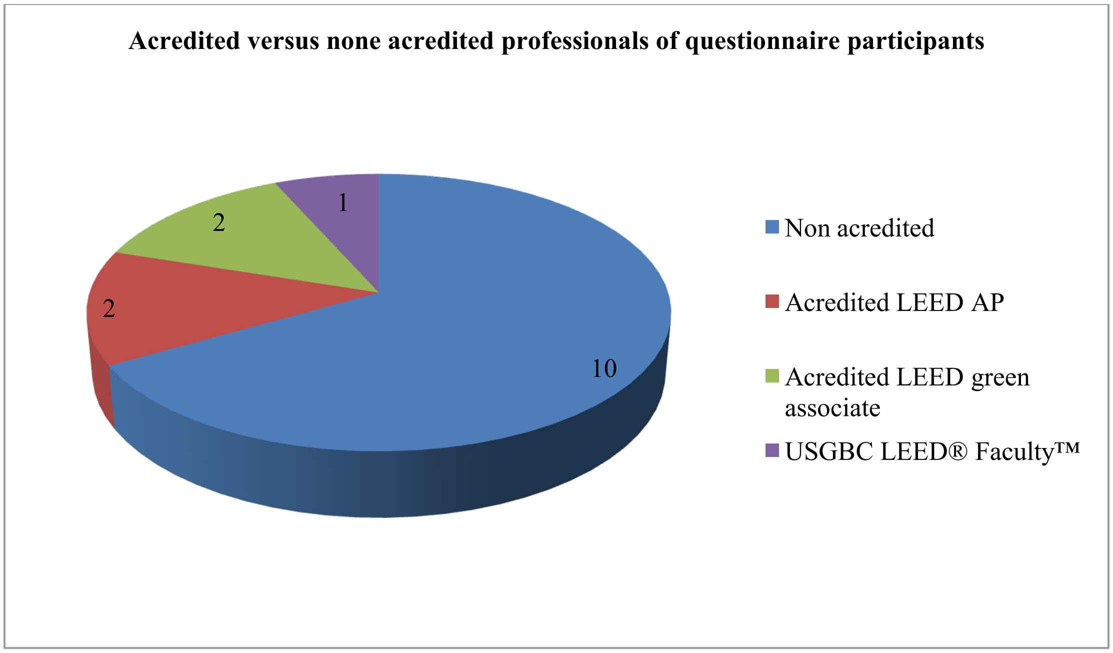


Figure 31 - Accredited versus none accredited professionals of questionnaire participants

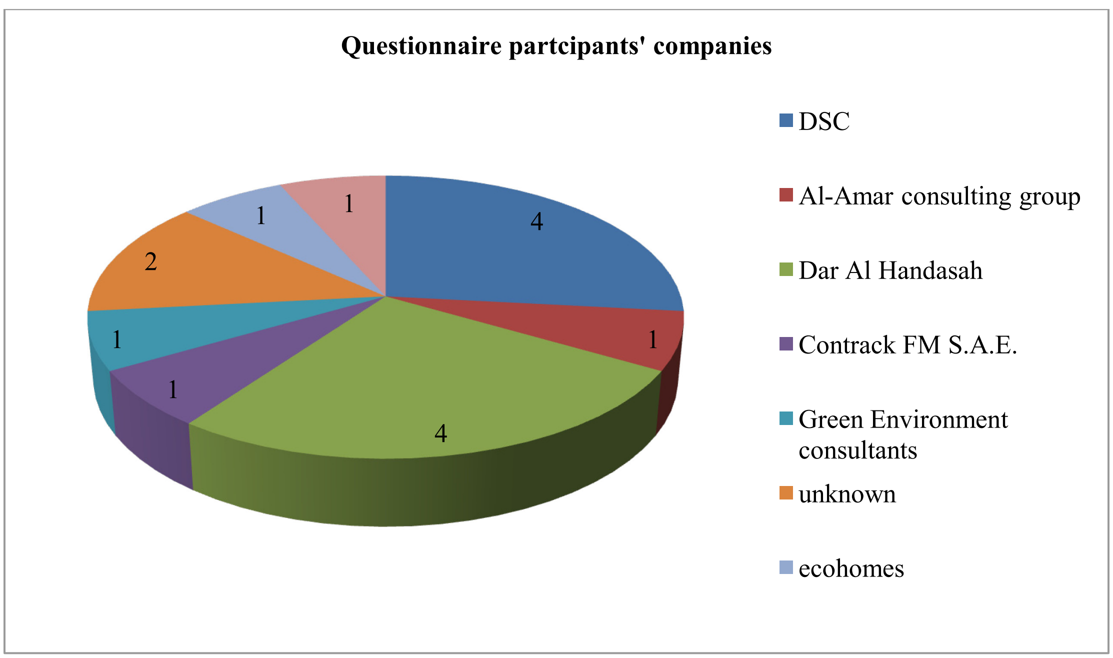


Figure 32 - Questionnaire participants'' companies

5.3 THE DIFFERENT EDITIONS OF THE QUESTIONNAIRE

The goal at first was to be comprehensive – covering all possible categories and credits covered by any of the four rating systems compared – but this brought out a very complex and long questionnaire to fill, which made the question of comprehensive versus practical come up.

In the next part, the different editions of the questionnaire are demonstrated by the energy credits table.

As shown in table 8, the first edition of the questionnaire was comprehensive of all the criteria that cover energy issues in any of the four rating systems compared earlier. The participants commented on the length and complexity of the questionnaire, yet some tried to completely fill it, but it was noticed that they gave most categories equal importance, which implies an unreliable answer. So, in order to keep quality, quantity had to be sacrificed thus came the final version with only the main categories as well as the energy and water use sub categories covered. This final version is shown in appendix A. Figures 34 and 35 show a sample from the energy use questionnaire page edition 1 and 2.

Table 9 – Questionnaire sample page for energy use – Edition 1

Please choose a number from 1 to 5 to comment on each sub-category's importance level compared to these following categories where; 0 = Prerequisite 1 = strongly dis-agree i.e unimportant 2 = dis-agree i.e less important 3 = equal i.e equally important 4 = agree i.e more important 5 = strongly agree i.e twice as important	Minimum energy performance	Improved Energy Performance	Reduced energy demand	Space Optimization	Response to Microclimate and Topography	Integration of Daylighting	Building Envelope	Energy Monitoring & Reporting	Integration of energy efficient systems and appliances	Lighting Zones & control	Renewable energy sources (solar, wind, biomass, or photovoltaics etc.)	Green power	Vertical Transportation (lifts, Escalators and Travelling Walkways)	Cold Storage equipment	Drying Space
Minimum energy performance															
Improved Energy Performance															
Reduced energy demand															
Space Optimization															
Response to Microclimate and Topography															
Integration of Daylighting															
Building Envelope															
Energy Monitoring & Reporting															
Integration of energy efficient systems and appliances															
Lighting Zones & control															
Renewable energy sources (solar, wind, biomass, or photovoltaics etc.)															
Green power															
Vertical Transportation (lifts, Escalators and Travelling Walkways)															
Cold Storage equipment															
Drying Space															

Comments:

5.4 THE PROCESS OF FILLING THE QUESTIONNAIRE

The questionnaire was sent by email to 46 participants from whom:

- 4 partially filled all tables for the older editions,
- 3 fully filled some tables,
- 4 fully filled all tables in old editions,
- 15 fully filled all tables in final edition and the rest didn't reply.
- Some of the participants filled different editions of the questionnaire.

5.5 AHP ANALYSIS

It was suggested by Saaty (1980) and called Analytic Hierarchy Process (AHP). This method allows us to determine the weights (significances) of hierarchically non-structured or particular hierarchical level criteria in respect of those belonging to a higher level.

The steps for an AHP analysis are ((Moore & Weatherford, 2001) *and* (Render & Stair Jr, 2000)):

Step 1: Develop the weights for the criteria by:

- developing a single pair-wise comparison matrix for the criteria;
- multiplying the values in each row together and calculating the nth root of said product;
- normalizing the aforementioned nth root of products to get the appropriate weights; and
- calculating and checking the Consistency Ratio (CR)

The Consistency Ratio (CR) tells the decision-maker how consistent he/she has been when making the pair-wise comparisons. Calculating the Consistency Ratio (CR) is a four-step process.

- First, the pair-wise comparison values in each column are added together (as the "Sum" values) and each sum is then multiplied by the respective weight (from the "Priority vector" column) for that criteria.
  - Note the row labeled "Sum*PV": Each value in this row shows the result of multiplying the respective sum by the respective weight for that criterion (in the column labeled "Priority vector").
- Second, "Sum*PV" of each column are added together. This value is known Lambda-max.
  - IMPORTANT NOTE: Unlike the weights for the criteria which must sum to one, Lambda-max will not necessarily equal one.
- Third, the Consistency Index (CI) is calculated. The formula is:

  CI = (Lambda-max –n) / (n–1) where n is the number of criteria or systems being compared.
- Fourth (and lastly), the Consistency Ratio (CR) is calculated by dividing the Consistency Index (CI) (from the previous step) by a Random Index (RI), which is determined from a lookup table. The Random Index (RI) is a direct function of the number of criteria or systems being considered.
- The table of Random Indices (RI) is shown below:

n	Random index (RI)
1	0.00
2	0.00
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45

In general, the Consistency Ratio (CR) is calculated as:

Consistency Ratio (CR) = Consistency Index (CI) / Random Index (RI)

- The Consistency Ratio (CR) tells the decision-maker how consistent he/she has been when making the pair-wise comparisons. A higher number means the decision-maker has been less consistent, whereas a lower number means the decision-maker has been more consistent.
- If the Consistency Ratio (CR) <0.10, the decision-maker's pair-wise comparisons are relatively consistent.
- If the Consistency Ratio (CR) > 0.10, the decision-maker should seriously consider re-evaluating his/her pair-wise comparisons –the source(s) of inconsistency must be identified and resolved and the analysis re-done.

Step 2: Develop the ratings for each decision alternative for each criterion by:

- developing a pair-wise comparison matrix for each criterion, with each matrix containing the pair-wise comparisons of the performance of decision alternatives on each criterion;
- multiplying the values in each row together and calculating the nth root of said product;
- normalizing the aforementioned nth root of product values to get the corresponding ratings; and
- calculating and checking the Consistency Ratio (CR)

During the second step of the AHP process, the decision-maker determines the ratings for each decision alterative for each criterion. There will be one pair-wise comparison matrix for each criterion. And within each matrix, the pair-wise comparisons will rate each system relative to every other system.

Step 3: Calculate the weighted average rating for each decision alternative.

- Choose the one with the highest score.

5.6 COMPARING THE DEVELOPED WEIGHTINGS WITH THE RATING SYSTEMS COMPARED INITIALLY

This will be explained in detail in chapter 6.

CHAPTER 6

RESULTS, DISCUSSIONS AND ANALYSIS

6.1 AHP ANALYSIS

6.1.1 GENERAL CATEGORIES

The participants were asked to fill in their opinion on the relative importance of each category to the other categories from 1 to 5 where 1 means unimportant, 2 means less important, 3 means equally important, 4 means more important and 5 means twice as important. Then their responses were transformed to a scale of 1/5, 1/3, 1, 3 and 5. Where 1/5 means unimportant, 1/3 means less important, 1 means equally important, 3 means more important and 5 means twice as important as shown in table 9.

Then the corresponding total of all the questionnaires answers was calculated by calculating the geometric mean as shown later. After that the AHP analysis was performed twice for the main categories only in order to validate the excel sheet used. This is shown in figures 10 to 13. The remaining part shows the second method of calculation and the final result.

The same process is repeated and shown in tables 14 and 15 for the energy usage sub categories and the water use sub categories. It can be noticed that the consistency index is much lower than 10% which means that the participants were concentrating while answering the questionnaire and that their answers are logical.

Table 10 - Questionnaire format for the general categories

Please choose a number as shown below to comment on each category's importance level compared to these following categories where; 1 = strongly dis-agree i.e unimportant 2 = dis-agree i.e less important 3 = equal i.e equally important 4 = agree i.e more important 5 = strongly agree i.e twice as important	Energy	Water	Pollution (emisssion, garbage, sewage…etc)	Materials (recycling, durability…)	Indoor Environmental Quality	Livable outdoors and transportation (promoting use of public transport to decrease co2 emissions)	Site ecology (effect of the building and its location on the natural systems in the area)	Other sustainable systems & processes (commissioning innovation, life cycle costing…)
Energy use								
Water use								
Pollution (emisssion, garbage, sewage…etc)								
Materials (recycling, durability…)								
Indoor Environmental Quality								
Livable outdoors and transportation (promoting use of public transport to decrease co2 emissions)								
Site ecology (effect of the building and its location on the natural systems in the area)								
Other sustainable systems & processes (commissioning, innovation, life cycle costing…)								

Comments:

GEOMETRIC MEAN OF THE QUESTIONNAIRES ANSWERES:

geometric mean: $b_{ij} = (a_{1ij} \cdot a_{2ij} \cdots a_{kij})^{\frac{1}{k}}$ k = number of participants

Geometric mean

	1	2	3	4	5	6	7	8
1	1	0.9	1.2	2.4	1.6	2.1	2.1	2.1
2	1	1	1.3	2.1	2.1	2.1	2.1	2.7
3	6/7	7/9	1	1.9	1.7	2.0	1.5	1.5
4	3/7	1/2	1/2	1	0.9	1.5	1.1	1.3
5	3/7	1/2	4/7	1 1/6	1	1.3	1.3	1.5
6	1/2	1/2	1/2	2/3	3/4	1	1.3	1.2
7	1/2	1/2	2/3	1	7/9	7/9	1	0.9
8	1/2	3/8	2/3	3/4	2/3	6/7	1	1

Participant #1

	1	2	3	4	5	6	7	8
1	1	1/3	1	1	1/3	1	1	1
2	3	1	3	3	3	3	3	3
3	1	1/3	1	1	1	1	1	1
4	1	1/3	1	1	1/3	3	3	1
5	3	1/3	1	3	1	3	3	3
6	1	1/3	1	1/3	1/3	1	1	1
7	1	1/3	1	1/3	1/3	1	1	1
8	1	1/3	1	1	1/3	1	1	1

Participant #2

	1	2	3	4	5	6	7	8
1	1	1	1/3	3	1	5	5	5
2	1	1	1/3	3	1	5	5	5
3	3	3	1	5	3	5	5	5
4	1/3	1/3	1/5	1	1/3	4	1	1
5	1/3	1	1/3	3	1	5	5	5
6	1/5	1/5	1/5	1/4	1/5	1	1	1
7	1/5	1/5	1/5	1	1/5	1	1	1
8	1/5	1/5	1/5	1	1/5	1	1	1

Participant #3

	1	2	3	4	5	6	7	8
1	1	3	1	5	5	5	3	5
2	1/3	1	1/3	1	3	5	3	5
3	1	3	1	3	3	5	5	5
4	1/5	1	1/3	1	1	3	3	3
5	1/5	1/3	1/3	1	1	5	3	3
6	1/5	1/5	1/5	1/3	1/5	1	1	3
7	1/3	1/3	1/5	1/3	1/3	1	1	1
8	1/5	1/5	1/5	1/3	1/3	1/3	1	1

Participant #4

	1	2	3	4	5	6	7	8
1	1	1	1/3	1	1	3	5	5
2	1	1	1	5	5	5	5	5
3	3	1	1	1	3	3	3	3
4	1	1/5	1	1	1/3	3	3	3
5	1	1/5	1/3	3	1	1	1	1
6	1/3	1/5	1/3	1/3	1	1	3	1
7	1/5	1/5	1/3	1/3	1	1/3	1	1
8	1/5	1/5	1/3	1/3	1	1	1	1

Participant #5

	1	2	3	4	5	6	7	8
1	1	1/3	3	3	1	3	1	3
2	3	1	5	5	5	5	4	5
3	1/3	1/5	1	3	1	5	1	3
4	1/3	1/5	1/3	1	1	1	1/3	1
5	1/3	1/5	1	1	1	5	1	3
6	1/3	1/5	1/5	1	1/5	1	1/3	1
7	1	1/4	1	3	1	3	1	5
8	1/3	1/5	1/3	1	1/3	1	1/5	1

Participant #6

	1	2	3	4	5	6	7	8
1	1	1	1	3	3	1	3	3
2	1	1	1	3	3	1	3	3
3	1	1	1	3	3	1	1	1
4	1/3	1/3	1/3	1	1	1/3	1/3	1
5	1/3	1/3	1/3	1	1	1/3	1/3	3
6	1	1	1	3	3	1	1	1
7	1/3	1/3	1	3	3	1	1	1
8	1/3	1/3	1	1	1/3	1	1	1

Participant #7

	1	2	3	4	5	6	7	8
1	1	3	1	3	3	1/3	1/3	1/5
2	1/3	1	3	3	3	1/3	1/3	1/5
3	1	1/3	1	3	5	3	1/3	1/3
4	1/3	1/3	1/3	1	1	1/3	1/3	1/3
5	1/3	1/3	1/5	1	1	1/3	1/3	1/3
6	3	3	1/3	3	3	1	5	1/3
7	3	3	3	3	3	1/5	1	1/3
8	5	5	3	3	3	3	3	1

Participant #8

	1	2	3	4	5	6	7	8
1	1	3	3	5	3	5	5	5
2	1/3	1	5	3	3	3	5	5
3	1/3	1/5	1	3	1	3	3	3
4	1/5	1/3	1/3	1	1	3	1	3
5	1/5	1/3	1	1	1	1	1/3	1
6	1/5	1/3	1/3	1/3	1	1	1	3
7	1/5	1/5	1/3	1	3	1	1	3
8	1/5	1/5	1/3	1/3	1	1/3	1/3	1

Participant #9

	1	2	3	4	5	6	7	8
1	1	1	1	3	3	1/3	1/3	3
2	1	1	1	3	3	1	1	3
3	1	1	1	3	3	1	3	3
4	1/3	1/3	1/3	1	3	1/3	1	3
5	1/3	1/3	1/3	1/3	1	1	1	1
6	3	1	1	3	1	1	3	3
7	3	1	1/3	1	1	1/3	1	1
8	1/3	1/3	1/3	1/3	1	1/3	1	1

Participant #10

	1	2	3	4	5	6	7	8
1	1	1/3	1	3	1	3	3	3
2	3	1	3	5	3	5	5	5
3	1	1/3	1	3	3	3	1	1
4	1/3	1/5	1/3	1	1	3	1	1
5	1/3	1/3	1/3	1	1	1	1	1
6	1/3	1/5	1/3	1/3	1	1	1	1
7	1/3	1/5	1	1	1	1	1	1
8	1/3	1/5	1	1	1	1	1	1

Participant #11

	1	2	3	4	5	6	7	8
1	1	5	1	3	3	1	1	1
2	1/5	1	1/3	1/3	1/3	1	1/3	1
3	1	3	1	1	1	1	1	1
4	1/3	3	1	1	1	1	1	1
5	1/3	3	1	1	1	1	1	1
6	1	1	1	1	1	1	1	1
7	1	3	1	1	1	1	1	1
8	1	1	1	1	1	1	1	1

Participant #12

	1	2	3	4	5	6	7	8
1	1	1/5	3	3	1	5	3	1
2	5	1	1/5	1/5	1/3	1/5	1/5	1
3	1/3	5	1	1	1	1	1/3	1/3
4	1/3	5	1	1	1	1	1/3	1
5	1/3	3	1	1	1	1/5	1	1
6	1/5	5	1	1	5	1	1	3
7	1/3	5	3	3	1	1	1	1/5
8	1	1	3	1	1	1/3	5	1

Participant #13

	1	2	3	4	5	6	7	8
1	1	1/3	1	3	1	3	3	1
2	3	1	3	5	3	3	3	3
3	1	1/3	1	1	1	1	1	1
4	1/3	1/5	1	1	1/3	1	1	1
5	1/3	1/3	1	3	1	3	3	1
6	1/3	1/3	1	1	1/3	1	3	1
7	1/3	1/3	1	1	1/3	1/3	1	1
8	1	1/3	1	1	1	1	1	1

Participant #14

	1	2	3	4	5	6	7	8
1	1	5	3	1	1	3	3	3
2	1/5	1	1	1	1	3	3	3
3	1/3	1	1	1	1	3	3	3
4	1	1	1	1	1	3	3	3
5	1	1	1	1	1	3	3	3
6	1/3	1/3	1/3	1/3	1/3	1	1/3	1/3
7	1/3	1/3	1/3	1/3	1/3	3	1	1/3
8	1/3	1/3	1/3	1/3	1/3	3	3	1

Participant #15

	1	2	3	4	5	6	7	8
1	1	1/5	1	1	3	3	5	3
2	5	1	3	3	5	5	5	3
3	1	1/3	1	1	1	1	3	1
4	1	1/3	1	1	3	3	3	1
5	1	1/5	1	1/3	1	1	3	1
6	1/3	1/5	1	1/3	1	1	3	1
7	1/5	1/5	1/3	1/3	1/3	1/3	1	1
8	1/3	1/3	1	1	1	1	1	1

AHP TRIAL 1

Table 11 - Pair wise comparisons among objectives/alternatives

	1	2	3	4	5	6	7	8
1	1.00	0.93	1.16	2.40	1.61	2.06	2.06	2.14
2	1.08	1.00	1.29	2.14	2.14	2.13	2.10	2.65
3	0.86	0.78	1.00	1.86	1.73	1.99	1.54	1.54
4	0.42	0.47	0.54	1.00	0.86	1.47	1.08	1.34
5	0.42	0.47	0.58	1.16	1.00	1.33	1.29	1.49
6	0.49	0.47	0.50	0.68	0.75	1.00	1.29	1.16
7	0.49	0.48	0.65	0.93	0.78	0.78	1.00	0.93
8	0.47	0.38	0.65	0.75	0.67	0.86	1.08	1.00

Table 12 - Normalized matrix

0.192	0.187	0.182	0.220	0.168	0.177	0.180	0.175
0.206	0.202	0.203	0.196	0.225	0.183	0.184	0.216
0.166	0.156	0.157	0.170	0.181	0.171	0.135	0.126
0.080	0.094	0.085	0.092	0.091	0.126	0.094	0.109
0.080	0.094	0.091	0.106	0.105	0.115	0.113	0.122
0.093	0.095	0.079	0.062	0.079	0.086	0.113	0.094
0.093	0.096	0.102	0.085	0.081	0.067	0.087	0.076
0.090	0.076	0.102	0.068	0.070	0.074	0.094	0.082

Table 13 - Developed weights

Weights		Products	Ratio
0.1851	19%	1.4850	8.0214
0.2018	20%	1.6165	8.0086
0.1579	16%	1.2655	8.0152
0.0964	10%	0.7732	8.0230
0.1032	10%	0.8277	8.0221
0.0876	9%	0.7003	7.9918
0.0860	9%	0.6881	8.0058
0.0820	8%	0.6560	7.9995
CI=	0	**CI/RI=**	0.0011

AHP TRIAL 2

	Energy use	Water use	Pollution (emisssion, garbage, sewage…etc)	Materials (recycling, durability…)	Indoor Environmental Quality	Livable outdoors and transportation	Site ecology	Other sustainable systems & processes
Energy use	1	0.9	1.2	2.4	1.6	2.1	2.1	2.1
Water use	1	1	1.3	2.1	2.1	2.1	2.1	2.7
Pollution (emisssion, garbage, sewage…etc)	6/7	7/9	1	1.9	1.7	2.0	1.5	1.5
Materials (recycling, durability…)	3/7	1/2	1/2	1	0.9	1.5	1.1	1.3
Indoor Environmental Quality	3/7	1/2	4/7	1 1/6	1	1.3	1.3	1.5
Livable outdoors and transportation	1/2	1/2	1/2	2/3	3/4	1	1.3	1.2
Site ecology	1/2	1/2	2/3	1	7/9	7/9	1	0.9
Other sustainable systems & processes	1/2	3/8	2/3	3/4	2/3	6/7	1	1
sum (col)	5.213	4.9621	6.3614	10.909	9.534	11.622	11.431	12.258

Normalization

normalized matrix; normalized principal Eigenvector

									1st	8th iteration
Energy use	0.1918	0.1873	0.182	0.2196	0.1684	0.1771	0.1801	0.1747	19%	**19%**
Water use	0.2064	0.2015	0.2026	0.1963	0.2246	0.1833	0.1836	0.2165	20%	**20%**
Pollution (emisssion, garbage, sewage…etc)	0.1657	0.1564	0.1572	0.1704	0.1812	0.1712	0.1351	0.1259	16%	**16%**
Materials (recycling, durability…)	0.0801	0.0941	0.0846	0.0917	0.0906	0.1265	0.0941	0.1093	10%	**9%**
Indoor Environmental Quality	0.0801	0.0941	0.091	0.1061	0.1049	0.1147	0.1128	0.1217	10%	**10%**
Livable outdoors and transportation	0.0932	0.0946	0.079	0.0623	0.0787	0.086	0.1128	0.0944	9%	**9%**
Site ecology	0.0932	0.096	0.1018	0.0852	0.0814	0.0668	0.0875	0.0758	9%	**9%**
Other sustainable systems & processes	0.0896	0.0759	0.1018	0.0684	0.0703	0.0743	0.0941	0.0816	8%	**8%**
Lambda	0.9689	1.0045	1.0107	1.0204	0.9436	1.024	1.0166	1.0207	8.009	principal Eigenvalue
n	8					CI			0.001	
						CR			0.1%	Consistency

Random Index

n	1	2	3	4	5	6	7	8
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41

Check

I*I

8.009							
	8.009						
		8.009					
			8.009				
				8.009			
					8.009		
						8.009	
							8.009

A-I*I

-7.0	0.9	1.2	2.4	1.6	2.0588	2.0588	2.1411
1.1	-7.0	1.3	2.1	2.1	2.1302	2.0987	2.6536
0.9	0.8	-7.0	1.9	1.7	1.9899	1.5439	1.5439
0.4	0.5	0.5	-7.0	0.9	1.4702	1.076	1.3404
0.4	0.5	0.6	1.2	-7.0	1.3335	1.2889	1.4922
0.5	0.5	0.5	0.7	0.7	-7.009	1.2889	1.1578
0.5	0.5	0.6	0.9	0.8	0.7759	-7.009	0.9294
0.467	0.3768	0.6477	0.746	0.6701	0.8637	1.076	-7.009

(A-I*I)x

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

As explained earlier, first the questionnaire was filled. The questionnaire format was shown in table 10. After that the participants' answers were converted from 1,2,3,4 and 5 to 1/5, 1/3, 1, 3 and 5. Then the geometric mean for all the answers was calculated. Following that, was the AHP analysis itself starting by the normalized matrix then the normalized principal Eigenvector was calculated till the sixth iteration. It can be noticed above that the consistency ratio equals 0.1% which is much less than the 10% limit. This generally means that the participants were answering consistently. Meaning that if one says that for example A>B and B> C then A must be > C. If the answer is not A>C then there is inconsistency in the answers.

RESULTS

Table

Element	Weights
Energy use	19%
Water use	20%
Pollution (emisssion, garbage, sewage…etc)	16%
Materials (recycling, durability…)	9%
Indoor Environmental Quality	10%
Livable outdoors and transportation	9%
Site ecology	9%
Other sustainable systems & processes	8%

Eigenvalue	lambda	8.009
Consistency Ratio	CR	0.1%

Matrix

	Energy use	Water use	Pollution (emisssion, garbage, sewage…etc)	Materials (recycling, durability…)	Indoor Environmental Quality	Livable outdoors and transportation	Site ecology	Other sustainable systems & processes	normalized principal Eigenvector
Energy use	1	0.9	1.2	2.4	1.6	2.1	2.1	2.1	18.6%
Water use	1	1	1.3	2.1	2.1	2.1	2.1	2.7	20.2%
Pollution (emisssion, garbage, sewage…etc)	6/7	7/9	1	1.9	1.7	2.0	1.5	1.5	15.9%
Materials (recycling, durability…)	3/7	1/2	1/2	1	0.9	1.5	1.1	1.3	9.4%
Indoor Environmental Quality	3/7	1/2	4/7	1 1/6	1	1.3	1.3	1.5	9.9%
Livable outdoors and transportation	1/2	1/2	1/2	2/3	3/4	1	1.3	1.2	8.8%
Site ecology	1/2	1/2	2/3	1	7/9	7/9	1	0.9	8.9%
Other sustainable systems & processes	1/2	3/8	2/3	3/4	2/3	6/7	1	1	8.3%

As shown above, the following weights were given to the general categories items:

Energy use	19%	Indoor environmental quality	10%
Water use	20%	Livable outdoors and transportation	9%
Pollution	16%	Site	9%
Materials	9%	Other sustainable systems and processes	8%

It can be noticed that both the Energy and water use got the highest weights with the water use having a slightly higher weight followed by the pollution with a 16% then all the other main categories with nearly equal weights.

6.1.2 ENERGY USAGE

Table 14 – Questionnaire format for energy usage sub categories

Please choose a number as shown below to comment on each category's importance level compared to these following categories where; 1 = strongly dis-agree i.e unimportant 2 = dis-agree i.e less important 3 = equal i.e equally important 4 = agree i.e more important 5 = strongly agree i.e twice as important	Abiding with minimum energy performance	Improved Energy Performance	Reduced energy demand (Space Optimization, Cool building strategy, Integration of Daylighting, Building Envelope)	Energy Monitoring & Reporting	Integration of energy efficient appliances	Renewable energy sources (solar, wind, biomass, or photovoltaic etc.)
Abiding with minimum energy performance standard levels						
Improved Energy Performance (use less energy)						
Reduced energy demand (Space Optimization, Cool building strategy, Integration of Daylighting, Building Envelope)						
Energy Monitoring & Reporting						
Integration of energy efficient appliances						
Renewable energy sources (solar, wind, biomass, or photovoltaics etc.)						

Comments:

GEOMETRIC MEAN OF THE QUESTIONNAIRES ANSWERS

geometric mean: $b_{ij} = (a_{1ij} \cdot a_{2ij} \cdots a_{kij})^{\frac{1}{k}}$ ber of participants

Geometric mean

	1	2	3	4	5	6
1	1	1.2	0.9	1.4	1.1	1.3
2	6/7	1	1.3	1.1	1.2	0.9
3	1 1/9	7/9	1	1.4	1.8	1.2
4	5/7	8/9	5/7	1	1.1	1.3
5	5/7	5/6	5/9	1	1	1.0
6	3/4	1 1/9	5/6	7/9	1	1

Participant #1

	1	2	3	4	5	6
1	1	1/3	1/5	1	1	1
2	3	1	1/3	1/3	1	1
3	5	3	1	1	1	3
4	1	3	1	1	1	3
5	1	1	1	1	1	1
6	1	1	1/3	1/3	1	1

Participant #2

	1	2	3	4	5	6
1	1	3	3	3	5	5
2	1/3	1	3	3	3	3
3	1/3	1/3	1	3	1	1
4	1/3	1/3	1/3	1	1/3	1/3
5	1/3	1/3	1	3	1	1
6	1/5	1/3	1	3	1	1

Participant #3

	1	2	3	4	5	6
1	1	1	1/3	1	1	1/3
2	1	1	1	3	3	1/3
3	3	1	1	1	5	1
4	1	1/3	1	1	5	1
5	1	1/3	1/5	1/5	1	1
6	3	3	1	1	1	1

Participant #4

	1	2	3	4	5	6
1	1	3	1	1	1	3
2	1/3	1	3	3	1	1
3	1	1/3	1	5	3	3
4	1	1/3	1/5	1	1	5
5	1	1	1/3	1	1	1
6	1/3	1	1/3	1/5	1	1

Participant #5

	1	2	3	4	5	6
1	1	5	1	1	1	3
2	1/5	1	1	1/3	1	3
3	1	1	1	5	5	5
4	1	3	1/5	1	1	5
5	1	1	1/5	1	1	1
6	1/3	1/3	1/5	1/5	1	1

Participant #6

	1	2	3	4	5	6
1	1	1/3	1/3	1	3	1
2	3	1	1	1	3	1
3	3	1	1	1	3	1
4	1	1	1	1	1	1
5	1	1/3	1/3	1	1	1
6	1	1	1	1	1	1

Participant #7

	1	2	3	4	5	6
1	1	1	3	5	1/3	3
2	1	1	1	3	1	3
3	1/3	1	1	3	1/5	1
4	1/5	1/3	1/3	1	1	5
5	1/5	1	5	1	1	5
6	1/3	1/3	1	1/5	1/5	1

Participant #8

	1	2	3	4	5	6
1	1	3	3	5	3	5
2	1/3	1	3	3	3	3
3	1/3	1/3	1	3	5	5
4	1/5	1/3	1/3	1	1	1
5	1/5	1/3	1/5	1	1	1
6	1/5	1/3	1/5	1	1	1

Participant #9

	1	2	3	4	5	6
1	1	1	1/3	3	1/3	1/3
2	1	1	1	3	1	1/3
3	3	1	1	3	3	1/3
4	1/3	1/3	1/3	1	1/3	1/3
5	1/3	1	1/3	3	1	1/3
6	3	3	3	3	3	1

Participant #10

	1	2	3	4	5	6
1	1	1	1/3	1/5	1	1/5
2	1	1	3	1/5	1	1/5
3	3	1/3	1	1/3	1	1/5
4	5	5	3	1	3	1/3
5	5	1	1	1/3	1	1/3
6	5	5	5	3	3	1

Participant #11

	1	2	3	4	5	6
1	1	1	1/3	1	3	3
2	1	1	3	3	5	3
3	3	1/3	1	1	3	1
4	1	1/3	1	1	3	1
5	1	1/5	1/3	1/3	1	1
6	1/3	1/3	1	1	1	1

Participant #12

	1	2	3	4	5	6
1	1	1/3	1	1	1/3	1
2	3	1	5	1	1	1/3
3	1	1/5	1	1/5	3	1
4	1	1	5	1	1/5	1
5	1	1	1/3	5	1	1
6	1	3	1	1	1	1

Participant #13

	1	2	3	4	5	6
1	1	3	3	1	1	3
2	1/3	1	1/3	1/3	1/3	1
3	1/3	3	1	1	1	3
4	1	3	1	1	4	3
5	1	3	1	1/4	1	3
6	1/3	1	1/3	1/3	1/3	1

Participant #14

	1	2	3	4	5	6
1	1	3	3	3	3	3
2	1/3	1	1/3	1/3	1/3	1/3
3	1/3	3	1	1	1	1
4	1/3	3	1	1	1	1
5	1/3	3	1	1	1	1
6	1/3	3	1	1	1	1

Participant #15

	1	2	3	4	5	6
1	1	1/5	1	1	1/5	1/5
2	5	1	1	1	1/3	1/3
3	1	1	1	1	1	1/3
4	1	1	1	1	1	1
5	1	3	1	1	1	1
6	5	3	3	1	1	1

AHP ANALYSIS

	Abiding with minimum energy performance standard levels	Improved Energy Performance (use less energy)	Reduced energy demand (Space Optimization, Cool building strategy, Integration of Daylighting, Building Envelope)	Energy Monitoring & Reporting	Integration of energy efficient appliances	Renewable energy sources (solar, wind, biomass, or photovoltaics etc.)
Abiding with minimum energy performance standard levels	1	1 1/6	8/9	1 2/5	1	1 1/3
Improved Energy Performance (use less energy)	6/7	1	1 2/7	1 1/8	1 1/5	8/9
Reduced energy demand (Space Optimization, Cool building strategy, Integration of Daylighting, Building Envelope)	1 1/9	7/9	1	1 2/5	1 4/5	1 1/5
Energy Monitoring & Reporting	5/7	8/9	5/7	1	1	1 2/7
Integration of energy efficient appliances	1	5/6	5/9	1	1	1
Renewable energy sources (solar, wind, biomass, or photovoltaics etc.)	3/4	1 1/9	5/6	7/9	0.96665	1
sum (col)	5.37433	5.77607	5.30209	6.58411	7.12418	6.75241

Normalization | normalized principal Eigenvector

	normalized matrix						1st	6th iteration
Abiding with minimum energy performance standard levels	0.18607	0.2004	0.16936	0.21063	0.151	0.19848	19%	**19%**
Improved Energy Performance (use less energy)	0.16075	0.17313	0.24304	0.16991	0.16811	0.13298	17%	**18%**
Reduced energy demand (Space Optimization, Cool building strategy, Integration of Daylighting, Building Envelope)	0.20721	0.13435	0.1886	0.21062	0.2509	0.17737	19%	**19%**
Energy Monitoring & Reporting	0.13417	0.15476	0.13601	0.15188	0.15394	0.18986	15%	**15%**
Integration of energy efficient appliances	0.17296	0.14456	0.10552	0.13849	0.14037	0.15321	14%	**14%**
Renewable energy sources (solar, wind, biomass, or photovoltaics etc.)	0.13884	0.1928	0.15747	0.11847	0.13569	0.1481	15%	**15%**

Lambda	0.99959	1.02293	1.02316	1.00089	1.01224	1.01173	**6.071**	**principal Eigenvalue**
n	**6**					CI	0.014	
						CR	**1.1%**	**Consistency**

Random Index

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Check

I*I

6.071					
	6.071				
		6.071			
			6.071		
				6.071	
					6.071

A-I*I

-5.1	1.2	0.9	1.4	1.1	1.34021
0.9	-5.1	1.3	1.1	1.2	0.89796
1.1	0.8	-5.1	1.4	1.8	1.1977
0.7	0.9	0.7	-5.1	1.1	1.28203
0.9	0.8	0.6	0.9	-5.1	1.0345
0.74615	1.11363	0.83493	0.78001	0.96665	-5.0706

(A-I*I)x

0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0

As described before, for the general categories, the same process was used to develop the weights for the energy use sub-categories.

RESULTS

Table

Element	Weights
Abiding with minimum energy performance standard levels	19%
Improved Energy Performance (use less energy)	18%
Reduced energy demand (Space Optimization, Cool building strategy, Integration of Daylighting, Building Envelope)	19%
Energy Monitoring & Reporting	15%
Integration of energy efficient appliances	14%
Renewable energy sources (solar, wind, biomass, or photovoltaics etc.)	15%

Eigenvalue	lambda	6.071
Consistency Ratio	CR	1.1%

Matrix	Abiding with minimum energy performance standard levels	Improved Energy Performance (use less energy)	Reduced energy demand (Space Optimization, Cool building strategy, Integration of Daylighting, Building Envelope)	Energy Monitoring & Reporting	Integration of energy efficient appliances	Renewable energy sources (solar, wind, biomass, or photovoltaics etc.)			normalized principal Eigenvector
Abiding with minimum energy performance standard levels	1	1.2	0.9	1.4	1.1	1.3			18.6%
Improved Energy Performance (use less energy)	6/7	1	1.3	1.1	1.2	0.9			17.7%
Reduced energy demand (Space Optimization, Cool building strategy, Integration of Daylighting, Building Envelope)	1 1/9	7/9	1	1.4	1.8	1.2			19.3%
Energy Monitoring & Reporting	5/7	8/9	5/7	1	1.1	1.3			15.2%
Integration of energy efficient appliances	5/7	5/6	5/9	1	1	1.0			14.2%
Renewable energy sources (solar, wind, biomass, or photovoltaics etc.)	3/4	1 1/9	5/6	7/9	1	1			15.0%
	-	-	-	-	-	-			
	-	-	-	-	-	-	-		

As shown above, the following weights were given to the general categories items:

Abiding with minimum energy performance standard levels	19%
Improved energy performance1	18%
Reduced energy demand	19%
Energy monitoring and reporting	15%
Integration of energy efficient appliances	14%
Renewable energy sources	15%

It can be noticed that energy performance and demand got the highest weights, while monitoring, efficient appliances and renewable energy got lower weights.

6.1.3 WATER USAGE

Table 15 – Questionnaire format for water usage sub categories

Please choose a number as shown below to comment on each category's importance level compared to these following categories where; 1 = strongly dis-agree i.e unimportant 2 = dis-agree i.e less important 3 = equal i.e equally important 4 = agree i.e more important 5 = strongly agree i.e twice as important	Minimum Interior Water Use Reduction	Water Efficient Equipment	Water conserving features-Major Leak Detection	Water conserving features-Strategies for Minimal Use Water for Cooling Towers	Water-efficient irrigation system	Water-efficient landscaping	Grey water
Minimum Interior Water Use Reduction							
Water Efficient Equipment							
Water conserving features-Major Leak Detection							
Water conserving features-Strategies for Minimal Use of Water for Cooling Towers							
Water-efficient irrigation system							
Water-efficient landscaping (plants)							
Grey water							

Comments:

GEOMETRIC MEAN OF THE QUESTIONNAIRES ANSWERS

geometric mean: $b_{ij} = (a_{1ij} \cdot a_{2ij} \cdots a_{kij})^{\frac{1}{k}}$ = number of participants

Geometric mean

	1	2	3	4	5	6	7
1	1	1.2	2.1	2.1	1.1	1.2	1.7
2	6/7	1	2.2	1.8	1.1	1.2	1.1
3	1/2	4/9	1	0.9	0.5	0.6	0.8
4	1/2	5/9	1	1	0.5	0.6	0.6
5	1/2	8/9	2	2	1	1.2	1.0
6	4/5	5/6	1 3/5	1 3/5	6/7	1	1.0
7	3/5	8/9	1 2/7	1 2/3	1	1	1

Participant #1

	1	2	3	4	5	6	7
1	1	1	3	1	1	1	3
2	1	1	1	3	1	1	3
3	1/3	1	1	1/3	1/3	1	3
4	1	1/3	3	1	1	3	3
5	1	1	3	1	1	3	3
6	1	1	1	1/3	1/3	1	3
7	1/3	1/3	1/3	1/3	1/3	1/3	1

Participant #2

	1	2	3	4	5	6	7
1	1	3	3	5	5	5	3
2	1/3	1	3	3	3	3	1
3	1/3	1/3	1	5	5	5	1
4	1/5	1/3	1/5	1	1	1	1/3
5	1/5	1/3	1/5	1	1	1	1/3
6	1/5	1/3	1/5	1	1	1	1/3
7	1/3	1	1	3	3	3	1

Participant #3

	1	2	3	4	5	6	7
1	1	1	3	5	1	1	1
2	1	1	3	3	1	3	1
3	1/3	1/3	1	3	1/3	1/3	1/3
4	1/5	1/3	1/3	1	1/3	1/3	1/3
5	1/5	1	3	3	1	1	1
6	1	1/3	3	3	1	1	1/3
7	1	1	3	3	1	3	1

Participant #4

	1	2	3	4	5	6	7
1	1	1	3	3	1	3	3
2	1	1	5	5	3	3	3
3	1/3	1/5	1	1	1	3	3
4	1/3	1/5	1	1	1	1	1
5	1/3	1/3	1	1	1	1	1/3
6	1/3	1/3	1/3	1	1	1	1/3
7	1/3	1/3	1/3	1	3	3	1

Participant #5

	1	2	3	4	5	6	7
1	1	5	5	3	1	1	5
2	1/5	1	5	5	1	1	5
3	1/5	1/5	1	1/3	1/5	1/5	1
4	1/3	1/5	3	1	1/3	2	1
5	1/3	1	5	3	1	1	1
6	1	1	5	1/2	1	1	1
7	1/5	1/5	1	1	1	1	1

Participant #6

	1	2	3	4	5	6	7
1	1	1	3	1	3	1	1
2	1	1	3	1	1/3	1	1
3	1/3	1/3	1	1	1/5	1	1/3
4	1	1	1	1	1/3	1	1/3
5	1	3	5	3	1	1	1/3
6	1	1	1	1	1	1	1/3
7	1	1	3	3	3	3	1

Participant #7

	1	2	3	4	5	6	7
1	1	1	3	1	1/5	1/3	3
2	1	1	1	1	1	1/3	3
3	1/3	1	1	1	1	1/3	5
4	1	1	1	1	1/3	1/5	3
5	1	1	1	3	1	1	5
6	3	3	3	5	1	1	5
7	1/3	1/3	1/5	1/3	1/5	1/5	1

Participant #8

	1	2	3	4	5	6	7
1	1	3	5	5	3	3	5
2	1/3	1	5	3	3	3	3
3	1/5	1/5	1	1	1/3	1/3	1/3
4	1/5	1/3	1	1	1/3	1/3	1/3
5	1/5	1/3	3	3	1	1/3	3
6	1/3	1/3	3	3	3	1	3
7	1/5	1/3	3	3	1/3	1/3	1

Participant #9

	1	2	3	4	5	6	7
1	1	3	3	3	3	3	1
2	1/3	1	1	1	3	1	1/3
3	1/3	1	1	1/3	1/3	1/3	1/3
4	1/3	1	3	1	1	1	1/3
5	1/3	1/3	3	1	1	1	1/3
6	1/3	1	3	1	1	1	1/3
7	1	3	3	3	3	3	1

Participant #10

	1	2	3	4	5	6	7
1	1	1	1/3	3	1	1	1/3
2	1	1	1	3	1	1	1/3
3	3	1	1	5	3	3	1
4	1/3	1/3	1/5	1	1/3	1/3	1/5
5	1/3	1	1/3	3	1	1	1/3
6	1	1	1/3	3	1	1	1/3
7	3	3	1	5	3	3	1

Participant #11

	1	2	3	4	5	6	7
1	1	1/3	1	1	1/5	1/5	1
2	3	1	1	1	1/5	1/5	1
3	1	1	1	1	1/5	1/5	1
4	1	1	1	1	1/5	1/5	1
5	1	5	5	5	1	3	5
6	5	5	5	5	1/3	1	5
7	1	1	1	1	1/5	1/5	1

Participant #12

	1	2	3	4	5	6	7
1	1	1	1/3	3	3	1	1
2	1	1	3	1	3	1	1/3
3	3	1/3	1	1/3	1	1/3	1/3
4	1/3	1	3	1	1	1/3	1/5
5	1/3	1/3	1	1	1	1	1/3
6	1	1	3	3	1	1	1
7	1	3	3	5	3	1	1

Participant #13

	1	2	3	4	5	6	7
1	1	1	3	3	1	3	3
2	1	1	3	3	1	3	1
3	1/3	1/3	1	3	1/3	1	1
4	1/3	1/3	1/3	1	1	3	1
5	1/3	1	3	1	1	3	1
6	1/3	1/3	1	1/3	1/3	1	1
7	1/3	1	1	1	1	1	1

Participant #14

	1	2	3	4	5	6	7
1	1	1	5	1	1	3	1
2	1	1	5	1	1	3	1
3	1/5	1/5	1	1/3	1/3	1/3	1/3
4	1	1	3	1	1/3	1/3	1/3
5	1	1	3	3	1	1	1
6	1/3	1/3	3	3	1	1	1
7	1	1	3	3	1	1	1

Participant #15

	1	2	3	4	5	6	7
1	1	1/5	1	1	1/3	1/3	1
2	5	1	1	1/3	1/3	1/3	1/3
3	1	1	1	1/3	1/3	1/3	1/3
4	1	3	3	1	1/3	1/3	1
5	1	3	3	3	1	1	3
6	3	3	3	3	1	1	3
7	1	3	3	1	1/3	1/3	1

AHP ANALYSIS

	Minimum Interior Water Use Reduction	Water Efficient Equipment	Water conserving features-Major Leak Detection	Water conserving features-Strategies for Minimal Use of Water for Cooling Towers	Water-efficient irrigation system	Water-efficient landscaping (plants)	Grey water
Minimum Interior Water Use Reduction	1	1 1/6	2 1/7	2 1/7	1 1/8	1 1/4	1 2/3
Water Efficient Equipment	6/7	1	2 2/9	1 4/5	1 1/8	1 1/5	1 1/9
Water conserving features-Major Leak Detection	1/2	4/9	1	1	1/2	5/8	7/9
Water conserving features-Strategies for Minimal Use of Water for Cooling Towers	1/2	5/9	1	1	1/2	5/8	3/5
Water-efficient irrigation system	8/9	8/9	2	2	1	1 1/6	1
Water-efficient landscaping (plants)	4/5	5/6	1 3/5	1 3/5	6/7	1	1
Grey water	5/6	1 3/5	1 3/5	6/7	1.005546	1	1
sum (col)	5 1/3	6.499369	11.55548	10.30458	6.126497	6.865359	7.136307

Normalization

normalized matrix; normalized principal Eigenvector

								1st	6th iteration
Minimum Interior Water Use Reduction	0.187787	0.178121	0.185266	0.207784	0.182635	0.181427	0.232769	19%	19%
Water Efficient Equipment	0.16221	0.153861	0.19171	0.173451	0.182623	0.175353	0.155958	17%	17%
Water conserving features-Major Leak Detection	0.087716	0.069454	0.086539	0.089693	0.084828	0.090677	0.108114	9%	9%
Water conserving features-Strategies for Minimal Use of Water for Cooling Towers	0.087705	0.086084	0.093632	0.097044	0.081563	0.091792	0.084319	9%	9%
Water-efficient irrigation system	0.16783	0.137518	0.166517	0.194207	0.163225	0.168626	0.139356	16%	16%
Water-efficient landscaping (plants)	0.150765	0.127806	0.139012	0.153994	0.140994	0.145659	0.139356	14%	14%
Grey water	0.155987	0.247155	0.137324	0.083827	0.164131	0.146467	0.140128	15%	16%
Lambda	1.028818	1.095189	1.016276	0.905033	0.978543	0.97506	1.1473	7.146	principal Eigenvalue
n	7					CI		0.024	
						CR		1.8%	Consistency

Random Index

n	1	2	3	4	5	6	7
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32

1st	0.192945	0.197443	0.192024	0.189616	0.193085	0.192493	0.192392	19.29%	-8.3E-04
	0.168862	0.166884	0.168583	0.169963	0.168264	0.168894	0.168845	16.86%	-2.1E-03
	0.087967	0.090017	0.08703	0.08624	0.087736	0.08752	0.087776	8.78%	-3.9E-04
	0.087838	0.087512	0.087862	0.088014	0.087691	0.087879	0.088119	8.78%	-1.0E-03
	0.160017	0.157776	0.159809	0.161856	0.159021	0.159986	0.160664	15.99%	-2.6E-03
	0.142104	0.141878	0.141745	0.142402	0.141651	0.141907	0.142514	14.20%	-4.8E-04
	0.160267	0.15849	0.162948	0.16191	0.162552	0.161321	0.159689	16.10%	7.5E-03
2nd	0.1932	0.193192	0.193199	0.193206	0.193197	0.1932	0.1932	19.32%	3.4E-04
	0.168506	0.16851	0.168507	0.168503	0.168508	0.168506	0.168506	16.85%	-1.1E-04
	0.087948	0.087944	0.087948	0.087951	0.087947	0.087949	0.087948	8.79%	1.9E-04
	0.087828	0.087828	0.087829	0.087828	0.087829	0.087828	0.087828	8.78%	-1.7E-05
	0.159722	0.159726	0.159724	0.159719	0.159725	0.159722	0.159721	15.97%	-1.5E-04
	0.142026	0.142026	0.142027	0.142026	0.142027	0.142026	0.142025	14.20%	-2.5E-06
	0.16077	0.160774	0.160766	0.160767	0.160766	0.160768	0.160772	16.08%	-2.6E-04
3rd	0.193199	0.193199	0.193199	0.193199	0.193199	0.193199	0.193199	19.32%	-4.8E-07
	0.168507	0.168507	0.168507	0.168507	0.168507	0.168507	0.168507	16.85%	2.3E-07
	0.087948	0.087948	0.087948	0.087948	0.087948	0.087948	0.087948	8.79%	-2.8E-07
	0.087828	0.087828	0.087828	0.087828	0.087828	0.087828	0.087828	8.78%	-1.3E-08
	0.159723	0.159723	0.159723	0.159723	0.159723	0.159723	0.159723	15.97%	1.5E-07
	0.142026	0.142026	0.142026	0.142026	0.142026	0.142026	0.142026	14.20%	-8.5E-08
	0.160769	0.160769	0.160769	0.160769	0.160769	0.160769	0.160769	16.08%	4.7E-07

4th	0.193199	0.193199	0.193199	0.193199	0.193199	0.193199	0.193199	**19.32%**	-2.4E-12
	0.168507	0.168507	0.168507	0.168507	0.168507	0.168507	0.168507	**16.85%**	1.0E-12
	0.087948	0.087948	0.087948	0.087948	0.087948	0.087948	0.087948	**8.79%**	-1.5E-12
	0.087828	0.087828	0.087828	0.087828	0.087828	0.087828	0.087828	**8.78%**	-1.0E-13
	0.159723	0.159723	0.159723	0.159723	0.159723	0.159723	0.159723	**15.97%**	5.6E-13
	0.142026	0.142026	0.142026	0.142026	0.142026	0.142026	0.142026	**14.20%**	-5.1E-13
	0.160769	0.160769	0.160769	0.160769	0.160769	0.160769	0.160769	**16.08%**	2.9E-12

5th	0.193199	0.193199	0.193199	0.193199	0.193199	0.193199	0.193199	**19.32%**	0.0E+00
	0.168507	0.168507	0.168507	0.168507	0.168507	0.168507	0.168507	**16.85%**	0.0E+00
	0.087948	0.087948	0.087948	0.087948	0.087948	0.087948	0.087948	**8.79%**	0.0E+00
	0.087828	0.087828	0.087828	0.087828	0.087828	0.087828	0.087828	**8.78%**	0.0E+00
	0.159723	0.159723	0.159723	0.159723	0.159723	0.159723	0.159723	**15.97%**	0.0E+00
	0.142026	0.142026	0.142026	0.142026	0.142026	0.142026	0.142026	**14.20%**	0.0E+00
	0.160769	0.160769	0.160769	0.160769	0.160769	0.160769	0.160769	**16.08%**	0.0E+00

6th	0.193199	0.193199	0.193199	0.193199	0.193199	0.193199	0.193199	**19.32%**	0.0E+00
	0.168507	0.168507	0.168507	0.168507	0.168507	0.168507	0.168507	**16.85%**	0.0E+00
	0.087948	0.087948	0.087948	0.087948	0.087948	0.087948	0.087948	**8.79%**	0.0E+00
	0.087828	0.087828	0.087828	0.087828	0.087828	0.087828	0.087828	**8.78%**	0.0E+00
	0.159723	0.159723	0.159723	0.159723	0.159723	0.159723	0.159723	**15.97%**	0.0E+00
	0.142026	0.142026	0.142026	0.142026	0.142026	0.142026	0.142026	**14.20%**	0.0E+00
	0.160769	0.160769	0.160769	0.160769	0.160769	0.160769	0.160769	**16.08%**	0.0E+00

Check	7.146						
I*I		7.146					
			7.146				
				7.146			
					7.146		
						7.146	
							7.146

A-I*I	-6.1	1.2	2.1	2.1	1.1	1.245565	1.661114
	0.9	-6.1	2.2	1.8	1.1	1.203861	1.112967
	0.5	0.5	-6.1	0.9	0.5	0.622528	0.771534
	0.5	0.6	1.1	-6.1	0.5	0.630183	0.601725
	0.9	0.9	1.9	2.0	-6.1	1.157676	0.994484
	0.8	0.8	1.6	1.6	0.9	-6.14622	0.994484
	0.8	1.6	1.6	0.9	1.0	1.005546	-6.14622

(A-I*I)x	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	0.0	0.0	0.0	0.0	0.0	0.0	0.0

As explained before, the same process was repeated to calculate the weights for the water use sub-categories.

RESULTS

Table

Element	Weights
Minimum Interior Water Use Reduction	19%
Water Efficient Equipment	17%
Water conserving features-Major Leak Detection	9%
Water conserving features-Strategies for Minimal Use of Water for Cooling Towers	9%
Water-efficient irrigation system	16%
Water-efficient landscaping (plants)	14%
Grey water	16%

Eigenvalue	lambda	7.146
Consistency Ratio	CR	1.8%

Matrix	Minimum Interior Water Use Reduction	Water Efficient Equipment	Water conserving features-Major Leak Detection	Water conserving features-Strategies for Minimal Use of Water for Cooling Towers	Water-efficient irrigation system	Water-efficient landscaping (plants)	Grey water	normalized principal Eigenvector
Minimum Interior Water Use Reduction	1	1.2	2.1	2.1	1.1	1.2	1.7	19.3%
Water Efficient Equipment	6/7	1	2.2	1.8	1.1	1.2	1.1	16.9%
Water conserving features-Major Leak Detection	1/2	4/9	1	0.9	0.5	0.6	0.8	8.8%
Water conserving features-Strategies for Minimal Use of Water for Cooling Towers	1/2	5/9	1	1	0.5	0.6	0.6	8.8%
Water-efficient irrigation system	1/2	8/9	2	2	1	1.2	1.0	16.0%
Water-efficient landscaping (plants)	4/5	5/6	1 3/5	1 3/5	6/7	1	1.0	14.2%
Grey water	3/5	8/9	1 2/7	1 2/3	1	1	1	16.1%
	-	-	-	-	-	-	-	

As shown above, the following weights were given to the general categories items:

Minimum interior water use reduction	19%
Water efficient equipment	17%
Leak detection	9%
Minimal use of water for cooling towers	9%
Water efficient irrigation systems	16%
Water efficient landscaping	14%
Grey water	16%

It can be noticed that the highest weight was given to reducing interior water use, followed by grey water and water efficient equipment and irrigation, then landscaping. The last was water conserving features.

6.2 SENSITIVITY ANALYSIS

In order to validate and refine the results, a sensitivity analysis was performed. The weights that were developed from the questionnaire and AHP analysis were added to the weights of the four rating systems initially compared with a different weight for each rating system. The different weight options for each rating system is shown below in table 16 and the different cases of weight combinations of the rating systems compared are shown in table 17. In cases 1 and 3, the international rating systems –GREEN GLOBES and LEED- were given lower weights than the regional rating systems- ESTIDAMA and BREEAM Gulf; due to the similarity of the environment of the countries they were designed for, to Egypt. In case 2, the original four rating systems were given equal weights, while in case 4, they were all equal except for BREEAM Gulf which was given a slightly higher weight; this is because of the noticed similarity of the weights developed by the AHP analysis to BREEAM Gulf weights. In case 5, only the weights developed from the AHP analysis were taken into account. In all 5 cases, the weights developed from the AHP analysis got a noticeably higher weight than the rest. The sensitivity analysis of the different cases developed is then shown in figure 33. From the tables and the figure referred to below, it can be noticed that all the cases lie in the same range, so the geometric mean as well as the average amount of the five cases proposed were calculated and plotted and compared to the weights that were developed using the AHP analysis in table 18 and figure 34.

Table 16 - Different weighting options for each rating system

Green Globes V.0						LEED V3-NC					
#0	#A	#B	#C	#D	#E	#0	#F	#G	#H	#I	#J
100%	5.00%	10.00%	15.00%	20.00%	30.00%	100%	5.00%	10.00%	15.00%	20.00%	30.00%
30.00%	1.500%	3.00%	4.500%	6.00%	9.00%	30.00%	1.500%	3.00%	4.500%	6.00%	9.00%
8.50%	0.425%	0.85%	1.275%	1.700%	2.550%	8.50%	0.425%	0.85%	1.275%	1.700%	2.550%
9.00%	0.450%	0.90%	1.350%	1.800%	2.700%	9.00%	0.450%	0.90%	1.350%	1.800%	2.700%
9.00%	0.450%	0.90%	1.350%	1.800%	2.700%	9.00%	0.450%	0.90%	1.350%	1.800%	2.700%
20.00%	1.000%	2.00%	3.000%	4.00%	6.000%	20.00%	1.000%	2.00%	3.000%	4.00%	6.000%
8.00%	0.400%	0.80%	1.200%	1.600%	2.400%	8.00%	0.400%	0.80%	1.200%	1.600%	2.400%
11.50%	0.575%	1.15%	1.725%	2.300%	3.450%	11.50%	0.575%	1.15%	1.725%	2.300%	3.450%
4.00%	0.200%	0.40%	0.600%	0.800%	1.200%	4.00%	0.200%	0.40%	0.600%	0.800%	1.200%

Estidama Buildings						BREEAM Gulf					
#0	#K	#L	#M	#N	#O	#0	#P	#Q	#R	#S	#T
100%	5.00%	10.00%	15.00%	20.00%	30.00%	100%	5.00%	10.00%	15.00%	20.00%	30.00%
22.91%	1.15%	2.29%	3.44%	4.58%	6.87%	15.06%	0.75%	1.51%	2.26%	3.01%	4.52%
21.79%	1.09%	2.18%	3.27%	4.36%	6.54%	27.26%	1.36%	2.73%	4.09%	5.45%	8.18%
7.82%	0.39%	0.78%	1.17%	1.56%	2.35%	12.62%	0.63%	1.26%	1.89%	2.52%	3.79%
12.29%	0.61%	1.23%	1.84%	2.46%	3.69%	9.55%	0.48%	0.96%	1.43%	1.91%	2.87%
11.17%	0.56%	1.12%	1.68%	2.23%	3.35%	13.89%	0.69%	1.39%	2.08%	2.78%	4.17%
6.15%	0.31%	0.61%	0.92%	1.23%	1.84%	2.59%	0.13%	0.26%	0.39%	0.52%	0.78%
8.94%	0.45%	0.89%	1.34%	1.79%	2.68%	10.93%	0.55%	1.09%	1.64%	2.19%	3.28%
8.94%	0.45%	0.89%	1.34%	1.79%	2.68%	5.82%	0.29%	0.58%	0.87%	1.16%	1.75%

Proposed Egyptian green building rating system				
#0	#1	#2	#3	
100%	50.00%	60.00%	75.00%	
18.59%	9.29%	11.15%	13.94%	Energy use
20.24%	10.12%	12.15%	15.18%	Water use
15.89%	7.94%	9.53%	11.92%	Pollution (emisssion, garbage, sewage…etc)
9.35%	4.68%	5.61%	7.01%	Materials (recycling, durability…)
9.90%	4.95%	5.94%	7.42%	Indoor Environmental Quality
8.81%	4.41%	5.29%	6.61%	Livable outdoors and transportation (promoting use of public transport to decrease co2 emissions)
8.89%	4.45%	5.34%	6.67%	Site ecology (effect of the building and its location on the natural systems in the area)
8.33%	4.16%	5.00%	6.25%	Other sustainable systems & processes (commissioning, innovation, life cycle costing…)

Table 17 - Different cases of weight combinations of the rating systems compared

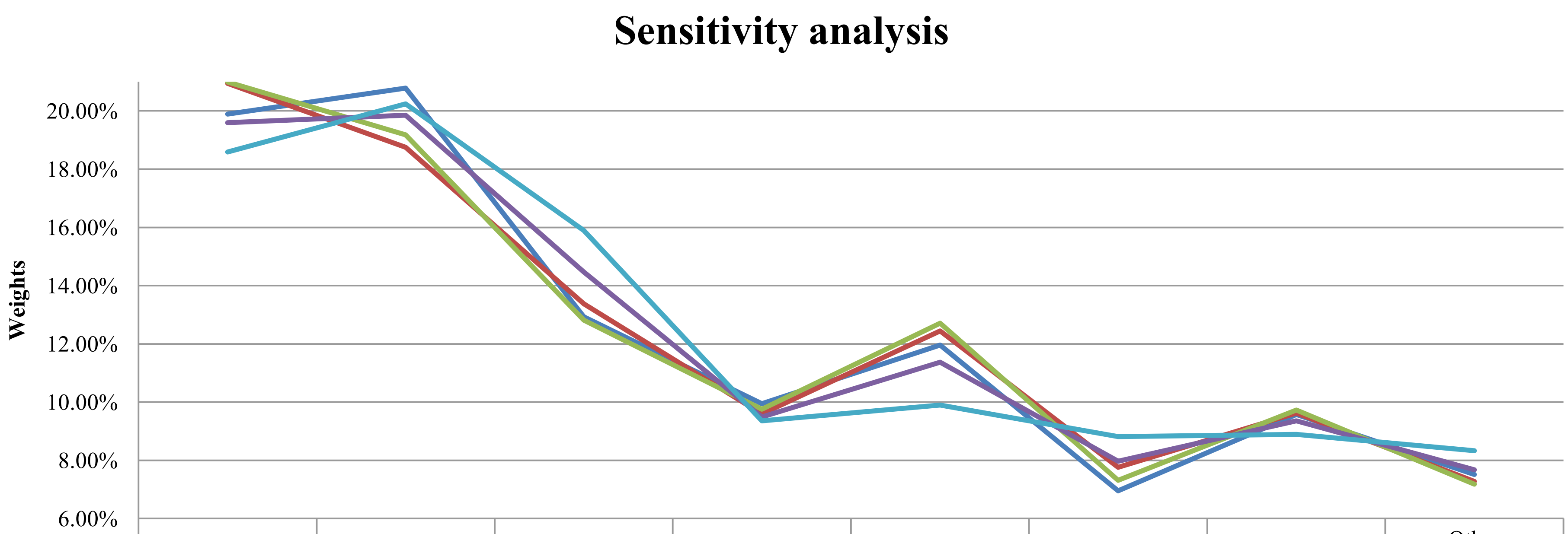
Case 1					
GG	LEED	ESTIDAMA	BREEAM Gulf	EGBRS	Result
5.00%	5.00%	20.00%	20.00%	50.00%	100.00%
1.50%	1.50%	4.58%	3.01%	9.29%	19.89%
0.43%	0.43%	4.36%	5.45%	10.12%	20.78%
0.45%	0.45%	1.56%	2.52%	7.94%	12.93%
0.45%	0.45%	2.46%	1.91%	4.68%	9.95%
1.00%	1.00%	2.23%	2.78%	4.95%	11.96%
0.40%	0.40%	1.23%	0.52%	4.41%	6.95%
0.58%	0.58%	1.79%	2.19%	4.45%	9.57%
0.20%	0.20%	1.79%	1.16%	4.16%	7.51%

Case 2					
GG	LEED	ESTIDAMA	BREEAM Gulf	EGBRS	Result
10.00%	10.00%	10.00%	10.00%	60.00%	100.00%
3.00%	3.00%	2.29%	1.51%	11.15%	20.95%
0.85%	0.85%	2.18%	2.73%	12.15%	18.75%
0.90%	0.90%	0.78%	1.26%	9.53%	13.38%
0.90%	0.90%	1.23%	0.96%	5.61%	9.60%
2.00%	2.00%	1.12%	1.39%	5.94%	12.44%
0.80%	0.80%	0.61%	0.26%	5.29%	7.76%
1.15%	1.15%	0.89%	1.09%	5.34%	9.62%
0.40%	0.40%	0.89%	0.58%	5.00%	7.27%

Case 3					
GG	LEED	ESTIDAMA	BREEAM Gulf	EGBRS	Result
10.00%	10.00%	15.00%	15.00%	50.00%	100.00%
3.00%	3.00%	3.44%	2.26%	9.29%	20.99%
0.85%	0.85%	3.27%	4.09%	10.12%	19.18%
0.90%	0.90%	1.17%	1.89%	7.94%	12.81%
0.90%	0.90%	1.84%	1.43%	4.68%	9.75%
2.00%	2.00%	1.68%	2.08%	4.95%	12.71%
0.80%	0.80%	0.92%	0.39%	4.41%	7.32%
1.15%	1.15%	1.34%	1.64%	4.45%	9.73%
0.40%	0.40%	1.34%	0.87%	4.16%	7.18%

Case 4					
GG	LEED	ESTIDAMA	BREEAM Gulf	EGBRS	Result
5.00%	5.00%	5.00%	10.00%	75.00%	100.00%
1.50%	1.50%	1.15%	1.51%	13.94%	19.59%
0.43%	0.43%	1.09%	2.73%	15.18%	19.85%
0.45%	0.45%	0.39%	1.26%	11.92%	14.47%
0.45%	0.45%	0.61%	0.96%	7.01%	9.48%
1.00%	1.00%	0.56%	1.39%	7.42%	11.37%
0.40%	0.40%	0.31%	0.26%	6.61%	7.97%
0.58%	0.58%	0.45%	1.09%	6.67%	9.36%
0.20%	0.20%	0.45%	0.58%	6.25%	7.67%

Case 5					
GG	LEED	ESTIDAMA	BREEAM Gulf	EGBRS	Result
0.00%	0.00%	0.00%	0.00%	100.00%	100.00%
0.00%	0.00%	0.00%	0.00%	18.59%	18.59%
0.00%	0.00%	0.00%	0.00%	20.24%	20.24%
0.00%	0.00%	0.00%	0.00%	15.89%	15.89%
0.00%	0.00%	0.00%	0.00%	9.35%	9.35%
0.00%	0.00%	0.00%	0.00%	9.90%	9.90%
0.00%	0.00%	0.00%	0.00%	8.81%	8.81%
0.00%	0.00%	0.00%	0.00%	8.89%	8.89%
0.00%	0.00%	0.00%	0.00%	8.33%	8.33%

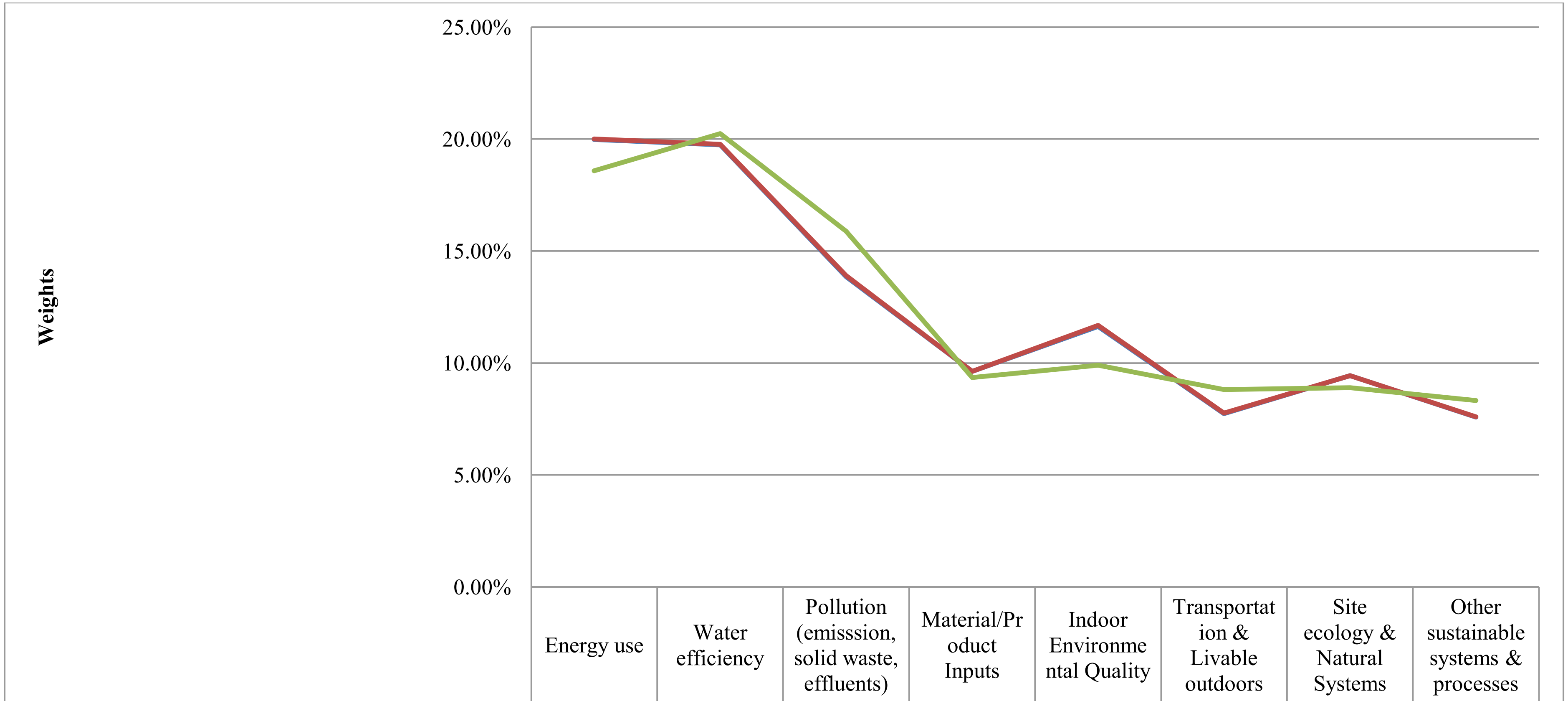


	Energy use	Water efficiency	Pollution (emisssion, solid waste, effluents)	Material/Product Inputs	Indoor Environmental Quality	Transportation & Livable outdoors	Site ecology & Natural Systems	Other sustainable systems & processes
Case 1	19.89%	20.78%	12.93%	9.95%	11.96%	6.95%	9.57%	7.51%
Case 2	20.95%	18.75%	13.38%	9.60%	12.44%	7.76%	9.62%	7.27%
Case 3	20.99%	19.18%	12.81%	9.75%	12.71%	7.32%	9.73%	7.18%
Case 4	19.59%	19.85%	14.47%	9.48%	11.37%	7.97%	9.36%	7.67%
Case 5	18.59%	20.24%	15.89%	9.35%	9.90%	8.81%	8.89%	8.33%

Figure 33 - Sensitivity analysis of the different cases developed

Table 18 – Geometric mean versus Average for all cases

Geometric mean							Average					
Case 1	Case 2	Case 3	Case 4	Case 5	Result		Case 1	Case 2	Case 3	Case 4	Case 5	Result
100.00%	100.00%	100.00%	100.00%	100.00%	100.00%		100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
19.89%	20.95%	20.99%	19.59%	18.59%	19.98%		19.89%	20.95%	20.99%	19.59%	18.59%	20.00%
20.78%	18.75%	19.18%	19.85%	20.24%	19.75%		20.78%	18.75%	19.18%	19.85%	20.24%	19.76%
12.93%	13.38%	12.81%	14.47%	15.89%	13.85%		12.93%	13.38%	12.81%	14.47%	15.89%	13.90%
9.95%	9.60%	9.75%	9.48%	9.35%	9.62%		9.95%	9.60%	9.75%	9.48%	9.35%	9.63%
11.96%	12.44%	12.71%	11.37%	9.90%	11.63%		11.96%	12.44%	12.71%	11.37%	9.90%	11.68%
6.95%	7.76%	7.32%	7.97%	8.81%	7.74%		6.95%	7.76%	7.32%	7.97%	8.81%	7.76%
9.57%	9.62%	9.73%	9.36%	8.89%	9.43%		9.57%	9.62%	9.73%	9.36%	8.89%	9.43%
7.51%	7.27%	7.18%	7.67%	8.33%	7.58%		7.51%	7.27%	7.18%	7.67%	8.33%	7.59%



	Energy use	Water efficiency	Pollution (emisssion, solid waste, effluents)	Material/Product Inputs	Indoor Environmental Quality	Transportation & Livable outdoors	Site ecology & Natural Systems	Other sustainable systems & processes
Geometric mean	19.98%	19.75%	13.85%	9.62%	11.63%	7.74%	9.43%	7.58%
Average	20.00%	19.76%	13.90%	9.63%	11.68%	7.76%	9.43%	7.59%
Proposed Egyptian green building rating system	18.59%	20.24%	15.89%	9.35%	9.90%	8.81%	8.89%	8.33%

Figure 34 - Geometric mean versus Average for all cases versus the proposed Egyptian green building rating system

6.3 FINAL PROPOSED WEIGHTS

It can be noticed from figure 34, that all the main categories' weights are almost equal except for the pollution and indoor air quality weights. So, it was decided to keep the generated weights form AHP as is with minor changes in the two above mentioned main categories by taking an average weight between the geometric mean and the developed weights. To sum up the final results; the proposed weights are as follows:

1. **Energy use:** 19%
2. **Water use:** 20%
3. **Pollution:** 15%
    - *An average value between the geometric mean and the developed weights*
4. **Materials:** 9%
5. **Indoor environmental quality:** 11%
    - *An average value between the geometric mean and the developed weights*
6. **Livable outdoors and transportation:** 9%
7. **Site ecology:** 9%
8. **Other sustainable systems and processes:** 8%

As for the energy use and water use sub-items, it was decided to use the developed weights from the AHP analysis as they represent the market needs and opinion on the importance of each factor to Egypt. They are what make this rating system suited to Egypt.

CHAPTER 7

CONCLUSIONS AND FUTURE WORK

7.1 CONCLUSIONS

1. There are many available rating systems on the market, yet from the comparative analysis performed in this thesis, one can deduce and notice that each rating system is accommodated to suite the environment for which it was designed for. For example, LEED is mainly concerned with energy use and gives lower importance to water while BREEAM Gulf does exactly the opposite thing. Surprisingly ESTIDAMA doesn't give water use a higher weight than energy despite of the nature of the environment there. None of the rating systems compared give a high weight on pollution except for BREEM Gulf. While Indoor environmental quality got low weight in all the rating systems except in Green Globes. This is why a new special rating system that suites and matches the needs of the construction industry and environment in Egypt needed to be developed.
2. To do that, a comprehensive list of categories and their sub categories that affect "greenness" of buildings needed to be developed. In order to develop it, a comparative analysis was done. From that comparison, both the weights of the categories weights for the four rating systems compared as well as the comprehensive list of sub categories was developed. From that list, the questionnaire was formed –in order to calculate the weights of each category that matches Egypt according to professionals in the industry- and from the weights calculated the validation and refining of the resulting weights was performed.

3. An AHP analysis was performed which gave out the weights of each category questioned. The participants gave the highest weight to water and energy use with a slightly higher weight to water use of 20% and 19% to energy use. This was due to their probable perception that water use affects not only itself but also energy use, because water treatment as well as transporting it requires energy.
4. Surprisingly pollution got a high weight of 16% -higher than the other rating systems- , but this is understandable because everyone living in Egyptian cities- specially Cairo - suffers from the pollution in its different forms. Another unexpected result was the relatively low weight –if compared with the other rating systems- for renewable energy sources of 15%. This might be because the participants saw that renewable energy is yet an area that is not effectively available in Egypt, thus more expensive than the normal energy option. One participant commented that there are two opinions in this matter; the first that renewable energy is a must as Egypt has sun and wind that can be used to generate electricity. The other is that the technology is not available yet, so it is still too expensive to convince people to switch from the subsidized governmental energy source.
5. The remaining five main categories materials, indoor environmental quality, livable outdoors and transportation, site ecology and other sustainable systems and processes got nearly equal weights of 8 and 10%. Participants probably felt indifferent in regards of the relative importance of each of them in comparison to the others. They viewed them nearly equally important.

6. The participants were familiar with green buildings and LEED. They were also from different fields, different companies and different areas of interest; thus can represent a diverse array from the market. Their answers were consistent, as shows in the AHP consistency index.
7. The main outcomes of this thesis are a list of main categories and sub categories with the weights for the main categories, the energy use sub categories and water use sub categories.

7.2 LIMITATIONS AND FUTURE WORK

1. The comparison developed between the four rating systems compared was on the basis of personal understanding of what each category meant. There may be some not fully understood or misplaced categories, but they don't have a major effect on the results acquired.
2. Also, the comparative analysis is based on the cross matching of the categories and their sub categories of the four rating systems. There may be sub categories that normally go under category X in rating system Y but for the sake of matching sub categories between rating systems were put under category Z. So, the total weight of each category is totally dependent on the organization of the categories listed in appendix B. This is accounted for by the code beside each sub category in the comparison.
3. Due to the size and complexity of the questionnaire, this thesis was only able to give weights for the main categories, energy use and water use categories, or otherwise compromise in the quality of the answers given. The rest of the categories need to be surveyed later in later research.

4. The cost of going “green” in Egypt was not covered in this thesis and needs to be addressed due to its major importance and effect on promoting this developed guideline for an Egyptian green building rating system.
5. The validation and adjustment of the weights developed depended mainly on the weights of the rating systems’ categories. The results may differ if other rating systems were included in the comparison. This needs further research, but the most relevant and important rating systems to Egypt – form the researcher’s point of view after researching thoroughly in this topic - were chosen. So the results acquired are valid for use.
6. Participants in the questionnaire might have given a slightly higher weight than the other rating systems gave to water use due to the recent water problem of Egypt with the Nile basin countries. This might have biased the answers on importance of categories a little towards water but the process of validation and refining of the results minimized that minor probability.
7. Renewable energy sources got a relatively low 15% than what the other rating systems gave it due to the scarcity of this technology in Egypt. If this area is improved the results and weights might change then. This area is of great importance and needs to further addressed and researched.
8. For prerequisites, the plan is to use the prerequisites in the four rating systems compared plus the developed weights. Some participants gave comments on which sub categories to be prerequisites, but this was not performed on a general basis. This might need to be addressed later, although the prerequisites don’t vary much between rating systems.

7.3 Major contributions

1. A comprehensive study of the available systems on the market.
2. A thorough and detailed comparison between the categories and credits of Green Globes, LEED V3 for New Construction, ESTIDAMA and BREEAM Gulf; listing similarities and differences in a comparative analysis.
3. Weights for the main categories, energy use and water use categories that represent the Egyptian construction industry professionals' opinion.

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- **Citation style used:**

APA 6th edition – American Psychological association 6th edition

Appendix A

Questionnaire

Thanks a lot for taking the time to fill this questionnaire

Please fill the following items as general information about you:	
Name:	
Telephone:	
Email:	-
Job title:	
Company name and interest in green buildings:	
There is an example table at first then three tables of questionnaires covering all the items that are generally in rating systems. If you have any comments or extra categories that you feel are missing or needed for the Egyptian green building rating system please write them down at the bottom of the questionnaire in the designated space for comments.	

Example for explanation

Please choose a number as shown below to comment on each category's importance level compared to these following categories where; 1 = strongly disagree i.e. unimportant 2 = disagree i.e. less important 3 = equal i.e. equally important 4 = agree i.e. more important 5 = strongly agree i.e. twice as important	Energy	Water	Pollution (emission, garbage, sewage…etc)	Materials	Indoor Environmental Quality	Livable outdoors	Site ecology	Other sustainable systems & processes
Energy use		1						
Water use	5							
Pollution (emission, garbage, sewage…etc)								
Materials (recycling, durability…)							3	
Indoor Environmental Quality								
Livable outdoors and transportation								
Site ecology				3				
Other sustainable systems & processes (commissioning, innovation, life cycle costing…)								

This is just for demonstration:

Water is twice as important than energy
Energy is unimportant in comparison to water
Site ecology is equally important to materials

Main categories

Please choose a number as shown below to comment on each category's importance level compared to these following categories where; 1 = strongly dis-agree i.e unimportant 2 = dis-agree i.e less important 3 = equal i.e equally important 4 = agree i.e more important 5 = strongly agree i.e twice as important	Energy	Water	Pollution (emisssion, garbage, sewage…etc)	Materials (recycling, durability…)	Indoor Environmental Quality	Livable outdoors and transportation (promoting use of public transport to decrease co2 emissions)	Site ecology (effect of the building and its location on the natural systems in the area)	Other sustainable systems & processes (commissioning, innovation, life cycle costing…)
Energy use								
Water use								
Pollution (emisssion, garbage, sewage…etc)								
Materials (recycling, durability…)								
Indoor Environmental Quality								
Livable outdoors and transportation (promoting use of public transport to decrease co2 emissions)								
Site ecology (effect of the building and its location on the natural systems in the area)								
Other sustainable systems & processes (commissioning, innovation, life cycle costing…)								

Comments:

Energy use

Please choose a number as shown below to comment on each category's importance level compared to these following categories where; 1 = strongly dis-agree i.e unimportant 2 = dis-agree i.e less important 3 = equal i.e equally important 4 = agree i.e more important 5 = strongly agree i.e twice as important	Abiding with minimum energy performance	Improved Energy Performance	Reduced energy demand (Space Optimization, Cool building strategy, Integration of Daylighting, Building Envelope)	Energy Monitoring & Reporting	Integration of energy efficient appliances	Renewable energy sources (solar, wind, biomass, or photovoltaic etc.)
Abiding with minimum energy performance standard levels						
Improved Energy Performance (use less energy)						
Reduced energy demand (Space Optimization, Cool building strategy, Integration of Daylighting, Building Envelope)						
Energy Monitoring & Reporting						
Integration of energy efficient appliances						
Renewable energy sources (solar, wind, biomass, or photovoltaics etc.)						

Comments:

Water efficiency

Please choose a number as shown below to comment on each category's importance level compared to these following categories where; 1 = strongly dis-agree i.e unimportant 2 = dis-agree i.e less important 3 = equal i.e equally important 4 = agree i.e more important 5 = strongly agree i.e twice as important	Minimum Interior Water Use Reduction	Water Efficient Equipment	Water conserving features-Major Leak Detection	Water conserving features-Strategies for Minimal Use of Water for Cooling Towers	Water-efficient irrigation system	Water-efficient landscaping	Grey water
Minimum Interior Water Use Reduction							
Water Efficient Equipment							
Water conserving features-Major Leak Detection							
Water conserving features-Strategies for Minimal Use of Water for Cooling Towers							
Water-efficient irrigation system							
Water-efficient landscaping (plants)							
Grey water							

Comments:

APPENDIX B

COMPARISON OF RATING SYSTEMS

Table key:

	Major credit
	Subdivisions of credits or strategies employed
	No equivalent

Green Globes V.0		**1000**	**100%**	**LEED V3 New construction**		**110**	**100%**	**ESTIDAMA Buildings**		**179.0**	**100%**	**BREEAM Gulf**		**116.0**	**100%**
Energy use		**300.0**	**30.00%**	**Energy and Atmosphere**		**31.0**	**28.18%**	**Resourceful Energy**		**41.0**	**22.91%**	**Energy**		**17.47**	**15.06%**
				EA PR 2	**Minimum energy performance**	0.0	**0.00%**	**RE-R1**	**Minimum Energy Performance**	**0.0**	**0.00%**	**Ene1**	**Reduction of CO_2 Emissions**	**9.02**	**51.63%**
					Design boiling to comply with ASHRAE/IESNA Standard 90.1 2007 or local energy code, whichever is more stringent.								Where the building demonstrates a percentage improvement, expressed in CO_2 emissions, above the base requirement for building design as set out in ASHRAE Energy Standard 90.1-2004.		
C.1	**Energy performance**: Achieve levels of performance better than that of a building meeting the 75% target defined by the EPA energy target finder:	100	**33.33%**	EA-1	**Optimize energy performance -** Choose applicable option	19	**61.29%**	**RE-1**	**Improved Energy Performance**	**15**	**36.59%**	**Ene5**	**Low or zero carbon technologies**	**2.41**	**13.80%**
	5% or more	10.0	3.33%										**1/4:** Where evidence provided demonstrates that a feasibility study considering Renewable and Low Emission (RLE) energy has been carried out and the results implemented **2/4:** Where evidence provided demonstrates that the first 1/4 has been achieved and 10% of total energy demand for the building/development is supplied from local RLE energy sources. **3/4:** Where in addition to the above 25% of total energy demand supplied from local RLE energy sources. **4/4:** Where in addition to the above 50% of total energy demand supplied from local RLE energy sources.		
	10% or more	20.0	6.67%		Improve by 12% for New Buildings or 8% for Existing Building Renovations	1.0	**3.23%**								
	15% or more	30.0	10.00%		Improve by 14% for New Buildings or 10% for Existing Building Renovations	2.0	**6.45%**								
					Improve by 16% for New Buildings or 12% for Existing Building Renovations	3.0	**9.68%**								
					Improve by 18% for New Buildings or 14% for Existing Building Renovations	4.0	**12.90%**								
	20% or more	40.0	13.33%		Improve by 20% for New Buildings or 16% for Existing Building Renovations	5.0	**16.13%**								
					Improve by 22% for New Buildings or 18% for Existing Building Renovations	6.0	**19.35%**								
	25% or more	50.0	16.67%		Improve by 24% for New Buildings or 20% for Existing Building Renovations	7.0	**22.58%**								
					Improve by 26% for New Buildings or 22% for Existing Building	8.0	**25.81%**								

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
					Renovations										
					Improve by 28% for New Buildings or 24% for Existing Building Renovations	9.0	**29.03 %**								
	30% or more	60.0	20.00 %		Improve by 30% for New Buildings or 26% for Existing Building Renovations	10.0	**32.26 %**								
					Improve by 32% for New Buildings or 28% for Existing Building Renovations	11.0	**35.48 %**								
	35% or more	70.0	23.33 %		Improve by 34% for New Buildings or 30% for Existing Building Renovations	12.0	**38.71 %**								
					Improve by 36% for New Buildings or 32% for Existing Building Renovations	13.0	**41.94 %**								
					Improve by 38% for New Buildings or 34% for Existing Building Renovations	14.0	**45.16 %**								
	40% or more	80.0	26.67 %		Improve by 40% for New Buildings or 36% for Existing Building Renovations	15.0	**48.39 %**								
					Improve by 42% for New Buildings or 38% for Existing Building Renovations	16.0	**51.61 %**								
	45% or more	90.0	30.00 %		Improve by 44% for New Buildings or 40% for Existing Building Renovations	17.0	**54.84 %**								
					Improve by 46% for New Buildings or 42% for Existing Building Renovations	18.0	**58.06 %**								
	50% or more	100.0	33.33 %		Improve by 48%+ for New Buildings or 44%+ for Existing Building Renovations	19.0	**61.29 %**								
C. 2	**Reduced energy demand**	114	**38.00 %**		**In order to comply with EA-1, energy modeling including space optimization, orientation, opaque assembly, fenestration and building envelope, is necessary. Performance**	0	**0.00%**	**RE -5**	**Peak Load Reduction**	**4**	**9.76 %**				

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf	116.0	100%
					based credit - no points allocated									
	Space Optimization	10	3.33%		Space Optimization	0	0.00%							
	Design floor area efficiently to fulfill the building's functional and spatial requirements, including circulation and services. Identify spaces that can accommodate more than one function or can be adapted to more or less intensive occupancy.	8.0	2.67%											
	Where a building design is based on future projections of increased occupant population, phase the construction process, distinguishing between immediate functional needs versus long-term projected needs. Provide adaptable structure and services, and load-bearing capacity for future building expansion.	2.0	0.67%											
	Response to Microclimate and Topography	24	**8.00%**					**RE-2**	**Cool Building Strategies**	**6**	**14.63%**			
	Use orientation and site features to optimize the effect of microclimatic conditions for heating or cooling.	8.0	2.67%											
	Base decision on wind and snow control studies for areas where this could be a problem, develop strategies - including	8.0	2.67%											

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
	location, use of site topography and orientation - to minimize the exposure to wind and the accumulation of snow.														
	Develop a building form that, site permitting, can benefit from natural or hybrid ventilation to provide natural cooling during the time of year when outdoor air is cooler than indoor air.	8.0	2.67%												
	Integration of Day lighting	35	11.67%		Orientation, opaque assembly and fenestration	0	0.00%								
	Implement a fenestration strategy that maximizes day lighting through building orientation, window-to-wall size ratios - that maximizes day lighting.	15.0	5.00%												
	Install window glazing which optimizes daylight (high visible transmittance, VT).	10.0	3.33%												
	Integrate electrical lighting design with day lighting, with controls to adjust the electrical lighting in response to available daylight, taking into account daily and seasonal variations in each lighting zone of the building.	10.0	3.33%												
	Building Envelope	35	**11.67%**		(EA-1 - Strategies => performance based, no points allocated for including the technology)	0	**0.00%**	**ID P-4**	**Building Envelope Verification**	**1**	**2.44%**				

	Green Globes V.0	1000	100%		LEED V3 New construction	110	100%		ESTIDAMA Buildings	179.0	100 %	BREEAM Gulf	116.0	100 %
	Design the building's thermal resistance of the exterior enclosure to exceed Federal and State Building Energy Codes for the walls by 25-30%.	5.0	**1.67%**		Opaque walls with high R-values									
	Design the building's thermal resistance of the exterior enclosure to exceed Federal and State Building Energy Codes for the roof by 25-30%.	5.0	1.67%		Roofs with R=23.8									
	Provide window glazing with a low U factor, and window treatments that enhance interior thermal comfort.	10.0	3.33%		High-performance glazing									
	Design the building to prevent groundwater and/or rain penetration into the building.	5.0	1.67%											
	Best air and vapor barrier practices to assure integrity of buildings envelope with respect:	2.0	0.67%											
	- meeting the requirements of local and national building codes	1.0	0.33%											
	- detailing of roof to wall air barrier connections.	1.0	0.33%											
	- Mock-ups and mock-up testing for air and vapor barrier systems.	1.0	0.33%											
	- Field review and testing for air and vapor barrier systems.	1.0	0.33%											
	- Prevent unwanted stack effect by	5.0	1.67%											

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
	appropriate sealing of the top, bottom and vertical shafts of the building.														
	Integration of Energy Sub-metering	10	**3.33%**	**EA-5**	**Measurement & verification**	3	**9.68%**	**RE-R2**	**Energy Monitoring & Reporting**	**0**	**0.00%**	**Ene2**	**Sub Metering of Substantial Energy Uses**	**0.60**	**3.43%**
	Provide sub-meeting of major energy uses (such as lighting, motions, hot water heaters, boilers, fans, cooling and humidification plant, computers and catering facilities) in buildings greater than 50,000 ft^2	10.0	**3.33%**		Comply with the installed equipment requirements for continuous metering per Option B,C and D of the 2001 International Performance Measurements & Verification Protocol (IPMVP), Vol I: Concepts and Options for Determining Energy and Water Savings								Where evidence is provided to demonstrate the provision of direct sub-metering of substantive energy uses within the building.		
												Ene3	**Sub Metering of high energy load Areas and Tenancy**	**0.60**	**3.43%**
													Where evidence provided demonstrates sub-metering of energy use by tenancy/areas is installed within the building.		
C.3	**Integration of energy efficient systems -** Specify energy efficient technologies, such as:	**66**	**22.00%**		(EA-1 - Strategies => performance based, no points allocated for including the technology)	0	**0.00%**	**RE-3**	**Energy Efficient Appliances**	**3**	**7.32%**	**Ene15**	**Provision of Energy Efficient White Goods**	**0.60**	**3.43%**
	- High-efficiency lamps and luminaries with electronic ballasts.	6.0	2.00%		Reduce power lighting densities (1.1 watt/SF)								**1st half:** Where evidence provided demonstrates the provision of energy-efficient domestic fridges and freezers or fridge-freezers, thus reducing the CO_2 emissions from appliance use in the building. **2nd half:** Where evidence provided demonstrates the provision of energy-efficient domestic washing machines, dishwashers, washer-dryers, tumble dryers, thus reducing the CO_2 emissions from appliance use in the building.		
	- lighting controls.	6.0	2.00%		Occupancy sensor controls and daylight dimming system							**Hea6**	**Lighting Zones & control**	**1.24**	**7.10%**
	- Energy-efficient HVAC equipment.	6.0	2.00%										Where evidence provided demonstrates that lighting, in all occupied areas, is zoned to allow separate occupant control.		
	- High-efficiency or condensing	8.0	2.67%		Modulating Condenser Boilers (93%										

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf	116.0	100%
	type boilers or other higher-efficiency heating sys. (e.g. infrared heating in industrial buildings)				nom. effic.)									
	- High efficiency chillers.	6.0	2.00%		High-efficiency Chillers (0.49 kw/ton)									
	- Energy-efficient hot water service systems.	6.0	2.00%											
	- building automation systems.	6.0	2.00%		Variable Speed Drive Fans at Air Handlers and Pumps, Variable Frequency Drive Cooling Tower Fans									
	- variable speed drives	6.0	2.00%		Premium Efficiency Motors									
	- Energy-efficient motors on fans/pumps.	6.0	2.00%											
	- Energy-efficient elevators.	4.0	1.33%		Under floor air distribution, energy recovery									
	- Other energy-saving systems or measures (i.e. displacement ventilation, cogeneration, heat recovery etc.).	6.0	2.00%		Waterside Economizer @ Air Cooling Towers									
					Wet bulb Reset at Cooling Towers									
					CO Control of Garage Ventilation Fans									
C.4	**Renewable energy sources** (solar, wind, biomass, or photovoltaic etc.) - select one of the 2	**20**	**6.67%**	**EA-2**	**On-site renewable energy**	**7**	**22.58%**	**RE-6**	**Renewable Energy**	**9**	**21.95%**			
					Supply at least 1% of building's total energy use through on-site renewable energy systems (i.e.: roof-mounted photovoltaic system)	1.0	**3.23%**							
					Supply at least 3% of building's total energy use	2.0	6.45%							
	- For more than 5% and less than 10% of the total load.	10.0	3.33%		Supply at least 5% of building's total energy use	3.0	9.68%							
					Supply at least 7% of building's total energy use	4.0	12.90%							
	- For more than 10% of the total load.	20.0	6.67%		Supply at least 9% of building's total energy use	5.0	16.13%							

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100 %	BREEAM Gulf		116.0	100 %
					Supply at least 11% of building's total energy use	6.0	19.35 %								
					Supply at least 13% of building's total energy use	7.0	22.58 %								
				EA-6	**Green power**	**2**	**6.45%**								
					Provide at least 50% of building's electricity from renewable sources by engaging in at least a two-year renewable energy contract.										
								RE-4	**Vertical Transportation**	**3**	**7.32 %**	**Ene8**	**Lifts**	**0.60**	**3.43 %**
													Where evidence provided demonstrates that the assessed developments passenger and/or goods lifts match motor output to passenger demand and returns excess energy to the grid or to meet other on site demand.		
												Ene9	**Escalators and Travelling Walkways**	**0.60**	**3.43 %**
													Where evidence provided demonstrates that escalators avoid unnecessary operation when there are no passengers, thereby minimizing energy consumption.		
												Ene7	**Cold Storage equipment**	**1.20**	**6.87 %**
													Where evidence provided demonstrates the energy efficient specification and operation of walk in cold food stores.		
												Ene18	**Drying Space**	**0.60**	**3.43 %**
													Where evidence provided demonstrates that space and posts/footings/fixings for drying clothes will be provided in a secure environment for each dwelling in the building. This may be external or internal.		
Water Use		**85.0**	**8.50%**	**Water Efficiency**		**10.0**	**9.09%**	**Precious Water**		**39.0**	**21.79 %**	**Water credits**		**31.62**	**27.26 %**
				WEPR-1	**Water use reduction-20% reduction**	**0**	**0.00%**	**PW-R1**	**Minimum Interior Water Use Reduction**	**0**	**0.00 %**				
D.1	**Water performance** - Achieve water use	**30**	**35.29 %**	**WE-3**	**Water use reduction**	**4**	**40.00 %**	**PW-1**	**Improved Interior Water Use Reduction**	**15**	**38.46 %**				

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100 %	BREEAM Gulf		116.0	100 %
	targets of (select one of 3):														
	- less than 35 gal / ft^2 / year or less than 66,000 gal / apartment / year, or less than 45 gal / student /year	18.0	**21.18 %**	WE-3.1	Water use reduction - 30%	2	20.00 %								
	- less than 20 gal / ft^2 / year or less than 33,000 gal / apartment / year, or less than 25 gal / student /year	24.0	28.24 %		Employ strategies that in aggregate use 30% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 and subsequent rulings by the Department of Energy, requirements of the Energy Policy Act of 2005, and the plumbing code requirements as stated in the 2006 editions of the Uniform Plumbing Code or International Plumbing Code.										
	- less than 10 gal / ft^2 / year or less than 11,000 gal / apartment / year, or less than 15 gal / student /year	30.0	35.29 %	WE-3.2	Water Use Reduction - 35%	3	30.00 %								
					Employ strategies that in aggregate use 35% less water than the water use baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992 and subsequent rulings by the Department of Energy, requirements of the Energy Policy Act of 2005, and the plumbing code requirements as stated in the 2006 editions of the Uniform Plumbing Code or International Plumbing Code.										
				WE-3.2	Water Use Reduction - 40%	4	40.00 %								
					Employ strategies that in aggregate use 40% less water than the water use baseline calculated for the building (not including										

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
					irrigation) after meeting the Energy Policy Act of 1992 and subsequent rulings by the Department of Energy, requirements of the Energy Policy Act of 2005, and the plumbing code requirements as stated in the 2006 editions of the Uniform Plumbing Code or International Plumbing Code.										
D. 2	**Water conserving features**	45	**52.94 %**		(WE-3 - Strategies => performance based, no points allocated for including the technology)	0	**0.00%**					**Wat 1**	**Water Consumption**	**9.49**	**30.01 %**
	Integration of Water Efficient Equipment	20	**23.53 %**												
	Provide water sub-metering of water uses for high-water-usage operations of occupancies such as boilers, cooing tower make-up lines, water-cooled air conditioning units or special laboratory operations.	4.0	**4.71%**		Strategies for WE 3.1			**PW-3**	**Water Monitoring & Leak Detection**	**4**	**10.26 %**		Where the specification includes taps, urinals, WCs and showers that consume less water in use than standard specifications for the same type of fittings.		
	Increase the building water-efficiency through the use of the following water-efficient equipment:				- Specifying 0.5 gym faucets at bathroom lavatories.							**Wat 2**	**Water Meter**	**3.16**	**9.99 %**
	- Low flush (LF) toilets (less than or equal to 1.6 gallons/flush).	4.0	4.71%		- specifying 1.0 gpm faucets at bathroom lavatories and 1.5 gpm faucets at pantry sinks.								Where information provided demonstrates that a water meter with a pulsed output will be installed on the mains supply to each building.		
	- Water-saving fixtures on faucets (2.0 gallons/min.) and showerheads (2.4 gallons/min.)	4.0	4.71%		Strategies for WE 3.2							**Wat 3**	**Major Leak Detection**	**3.16**	**9.99 %**
	- urinals with proximity detectors or waterless urinals where	4.0	4.71%		- 0.5 gpm faucets at bathroom lavatories								Where evidence provided demonstrates that a leak detection system is specified or installed.		

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100 %	BREEAM Gulf		116.0	100 %
	applicable (e.g. offices)														
	- water efficient (H-axis) washing machines + low water dishwaters (8 gallons) where applicable (i.e. in MURBs)	4.0	4.71%		- Infrared sensor controls on lavatory faucets (hard-wired system).							**Wat 4**	**Sanitary Supply Shut Off**	**3.16**	**9.99 %**
					- 0.5 gpf urinals (including hard-wired electronic controls).								Where evidence provided demonstrates that proximity detection shut off is provided to the water supply to all urinals and WC's		
					- 2.0 gpm showers										
	Strategies for Minimal Use of Water for Cooling Towers	10	11.76 %												
	Where applicable install features to minimize the consumption of make-up water for wet-cooling towers.	10.0	11.76 %												
				WE-1	**Water-efficient landscaping**	**4**	**40.00 %**	**PW-2.1**	**Exterior Water Use Reduction: Landscaping**	**8**	**20.51 %**	**Wat 6**	**Irrigation Systems**	**3.16**	**9.99 %**
	Strategies for minimal use of water for irrigation (select ONE within 2.6 below, if applicable)	15	**17.65 %**	WE-1.1	Water-Efficient Landscaping - 50% reduction in potable water use	2	**20.00 %**	**PW-R2**	**Exterior Water Monitoring**	**0**	**0.00 %**		Where evidence provided demonstrates that low-water irrigation systems are specified/installed, or where planting and landscaping is irrigated reclaimed water.		
	Specify a water-efficient irrigation system (e.g. high efficiency technology, rain sensors).	5.0	**5.88%**		- Limit turf grass to 15% of the site's total planting area. - Employ timer and rain sensor controls for the pop-up sprinkler irrigation system. - Specify groundcovers with low water consumption needs			**PW-2.3**	**Exterior Water Use Reduction: Water Features**	**4**	**10.26 %**				
	Specify irrigation using a portion of non-potable water (captured rainwater or recycled site water).	3.0	**3.53%**												
	Provide landscaping that can withstand extreme local weather conditions and require minimal irrigation.	5.0	**5.88%**					**PW-2.2**	**Exterior Water Use Reduction: Heat Rejection**	**8**	**20.51 %**				
				WE-1.2	Water-Efficient Landscaping -	4	**40.00 %**								

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
					Totally eliminate potable water use										
	Specify irrigation using all non-potable water (i.e. captured rainwater or recycled site water).	5.0	5.88%		- Use only captured rain or recycled site water to eliminate all potable water use for site irrigation.										
					- Do not Install permanent landscape irrigation systems.										
D.3	**On-site treatment of water (greywater system, on-site wastewater treatment)**	**10**	**11.76 %**	**WE-2**	**Innovative wastewater technologies**	**2**	**20.00 %**					**Wat 5**	**Water Recycling**	**9.49**	**30.01 %**
	Where feasible, integrate a greywater collection, storage and distribution system to collect, store, treat and redistribute laundry and bathing effluent for toilet flushing, irrigation, janitorial cleaning, cooling and car washing.	5.0	5.88%		Reduce use of municipal potable water for buildings, sewage conveyance by min. 50% - OR treat 100% of wastewater on site to tertiary standards								Where evidence provided demonstrates the specification of systems that collect, store, and where necessary, treat greywater for WC and urinal flushing purposes.		
	Where feasible, integrate a biological waste treatment system for the site and building such as peat moss drain field, constructed wetlands, aerobic treatment systems, solar agatic waste systems (or living machines), and compositing or eco-logically-based toilets.	5.0	**5.88%**												
Pollution (emission, solid waste, effluents)		**90.0**	**9.00%**			**6.0**	**5.45%**	**Stewarding Materials**		**14.0**	**7.82 %**	**Pollution credits**		**14.64**	**12.62 %**
												Wat 7	**Vehicle Wash**	**3.16**	**21.58 %**
													Where evidence provided demonstrates that vehicle washing facilities include a		

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100 %	BREEAM Gulf		116.0	100 %
													water reclaim system.		
								LBi-R3	**Legionella Prevention**	**0**	**0.00 %**	**Hea12**	**Microbial Contamination**	**1.24**	**8.47 %**
													Where evidence provided demonstrates that the risk of waterborne and airborne legionella contamination has been minimized.		
E.5	**Reduction, reuse and recycling of demolition waste**	**5**	**5.56%**	**MR-2**	**Construction waste management**	**2**	**33.33 %**	**SM-R2 & 13**	**Construction waste management**			**Wst1**	**Construction Site Waste Management**	**2.58**	**17.62 %**
	Develop and implement a construction, demolition and renovation waste management plan.	5.0	**5.56%**	MR-2.1	Construction waste management divert 50% from disposal	1	**16.67 %**	**SM-R2**	**Basic Construction Waste Management**	**0**	**0.00 %**		Where evidence provided demonstrates the production and implementation of a Site Waste Management Plan (SWMP) where issues such as sorting, reuse, and recycling are considered.		
					Develop a Construction Waste Management Plan (Costs vary based on project scope, site, experience of contractors, local landfill fees and recycling infrastructure, local laws)										
				MR-2.2	Construction waste management divert 75% from disposal	2	**33.33 %**	**SM-13**	**Improved Construction Waste Management**	**2**	**14.29 %**	**Wst2**	**Recycled Aggregates**	**0.64**	**4.37 %**
					Extension of strategy for Credit 2.1 to cover 75% 0f construction waste								Where significant use of crushed aggregate, crushed masonry or alternative aggregates (manufactured from recycled materials) are specified for 'high grade' aggregate uses (such as the building structure, ground slabs, roads, etc.).		
E.6	**Recycling and compositing facilities**	**10**	**11.11 %**	**MRPR-1**	**Storage & collection of recyclables**	**0**	**0.00%**	**SM-R3**	**Basic Operational Waste Management**	**0**	**0.00 %**	**Wst3**	**Storage of Recyclable Waste**	**1.29**	**8.81 %**
	Provide adequate handling and storage facilities for recycling and compositing for future occupants to recycle materials and compost organic waste.	10.0	**11.11 %**		Provide easily accessible areas for sorting, storing and collecting recyclables.								**1st half:** Where a central, dedicated storage space is provided for materials that can be recycled. This can be either within the building itself, or on site using skips, (provided there is good access for collections and it is within easy reach of the building). **2nd half:** Where, in addition, policies/procedures have been established at the		

Green Globes V.0		**1000**	**100%**	**LEED V3 New construction**		**110**	**100%**	**ESTIDAMA Buildings**		**179.0**	**100 %**	**BREEAM Gulf**		**116.0**	**100 %**
													design/construction stages which: a. include procedures for collection and recycling of consumables; b. Are endorsed at board level; c. Are or will be operational at a local level.		
								SM-14	**Improved Operational Waste Management**	**2**	**14.29 %**	**Wst4**	**Compactor / Baler**	**0.64**	**4.37 %**
													Where evidence provided demonstrates that either a compactor or baler is provided for compacting/baling waste generated on site and a. A water outlet is provided for cleaning b. The development achieves the first credit for storage of recyclable waste (Wst3)		
F.1	**Air emissions (low emission burners)**	**15**	**16.67 %**					**RE-7**	**Global Warming Impacts of Refrigerants & Fire Suppression Systems**	**4**	**28.57 %**	**Pol1**	**Refrigerant GWP - Building Services**	**1.02**	**6.97 %**
	Specify low-NO_x boilers and furnaces, which comply with ASME codes.	15.0	**16.67 %**										Where evidence provided demonstrates the use of refrigerants with a global warming potential (GWP) of less than 5 or where there are no refrigerants specified for use in building services.		
F.2	**Ozone depletion**	**25**	**27.78 %**	**EAP R-3, EA-4**	**Refrigerant management**	**2**	**33.33 %**	**RE-R3**	**Ozone Impacts of Refrigerants & Fire Suppression Systems**	**0**	**0.00 %**	**Pol2**	**Preventing Refrigerant Leaks**	**2.03**	**13.87 %**
	Select refrigeration systems that avoid the use of ozone-depleting substances (ODS) and potent industrial greenhouse gases (PIGGs).	20.0	**22.22 %**	EAP R-3	Fundamental refrigerant management	0	0.00%						**1st half:** Where evidence provided demonstrates that refrigerant leaks can be detected or where there are no refrigerants specified for use in the building or development. **2nd half:** Where evidence provided demonstrates that the provision of automatic refrigerant pump down is made to a heat exchanger (or dedicated storage tanks) with isolation valves or where there are no refrigerants		

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100 %	BREEAM Gulf		116.0	100 %
													specified for the development.		
	Choose one of 2: - Select refrigerants that have an ozone-depleting potential (ODP) less than 0.05.	10.0	11.11 %		Eliminate use of CFC-based refrigerants in HVAC&R systems.							**Pol3**	**Refrigerant GWP - Cold Storage**	**0.00**	**0.00 %**
	- Select refrigerants that have an ozone-depleting potential (ODP) equal to 0.	15.0	16.67 %	EA-4	Enhanced refrigerant management	2	33.33 %						Where evidence provided demonstrates the use of refrigerants with a global warming potential (GWP) of less than 5 within cold storage systems.		
	Ensure air-conditioning systems complies with the requirements of the Safety Code for Mechanical Refrigeration, ASHRAE 15 - 1994.	5.0	5.56%		Install base building level HVAC and refrigeration equipment and fire suppression systems that do not contain HCFC's or Halons or ozone-depleting substances.							**Pol9**	**Refrigerant ODP**	**1.02**	**6.97 %**
													Where evidence provided demonstrates the use of refrigerants with an Ozone Depleting Potential (ODP)of less than 5 or where there are no refrigerants specified for use in building services.		
												Pol10	**Refrigerant ODP - Cold Storage**	**0.00**	**0.00 %**
													Where evidence provided demonstrates the use of refrigerants with an Ozone Depleting Potential (ODP) of less than 5 within cold storage systems.		
F.3	**Avoiding sewer and waterway contamination**	**10**	**11.11 %**	**SS-6.2**	**Storm water design, quality control**	**1**	**16.67 %**	**PW-4**	**Storm water Management (see below)**	**4**	**28.57 %**	**Pol6**	**Minimizing Watercourse Pollution**	**1.02**	**6.97 %**
	Prevent storm or wastewater discharges of toxic or harmful materials (solids or sludge, floating debris and oil or scum) into public	10.0	**11.11 %**		Implement a storm water management plan that results in treatment sys. designed to remove 80% of the ave. annual post-development total suspended solids (TSS), and 40% of the average annual								Where evidence provided demonstrates that onsite treatment such as oil separators/interceptors or filtration have been specified for areas at risk from pollution, i.e. vehicle maneuvering		

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100 %	BREEAM Gulf		116.0	100 %
	utilities.				post-development total phosphorous (TP), and use Best Management Practices (BMPs) in EPA's Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters (EPA 840-B-92-002 1/93) or the local government's BMP document (whichever is more stringent).								areas, car parks, waste disposal facilities, delivery facilities, plant areas or window cleaning run-off areas.		
F.4	**Pollution minimization (storage tanks, PBCs, radon, asbestos, pest management, hazardous materials)**	**25**	**27.78 %**					**SM-R1**	**Hazardous Materials Elimination**	**0**	**0.00 %**				
	Integration of Complaint Storage Tanks	2	2.22%												
	Ensure compliance with the nationally recognized standards such as those developed by the Underwriters Laboratory (U.L.) the American National Standards Institute (ANSI), the American Petroleum Institute (API), the American Society for Testing and Materials (ASTM), the American Society of Mechanical Engineers (ASME), the Street Tank Institute (STI), the National Association of Corrosion Engineers (NACE), or the National Fire Protection Association (NFPA).	2.0	2.22%												
	Control of the other pollutants	3	3.33%												

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100 %	BREEAM Gulf		116.0	100 %
	(PCBs, Asbestos, Radon)														
	In the case of a retrofit, regulatory comply with regulations for all PCBs present in the building.	1.0	1.11%												
	In the case of a retrofit, contain, remove, or eliminate asbestos and asbestos-containing materials in compliance with all applicable state and local regulations?	1.0	1.11%												
	Prevent the accumulation of harmful chemicals and gases such as radon and methane in spaces below the substructure, and their penetration into the building.	1.0	1.11%												
	Integrated Pest Management	10	11.11 %												
	Protect components, materials and the protection of structural openings to avoid infestation by pests (rodents, insects, termites and other pests).	10.0	11.11 %												
	Storage and control of hazardous materials	10	**11.11 %**	**EQ-5**	**Indoor chemical & pollutant source control**	**1**	**16.67 %**	**SM-15**	**Organic Waste Management**	**2**	**14.29 %**				
					- Employ permanent entry way systems (grills, grates, etc.)										
	Design secure and appropriately-ventilated storage areas for hazardous and flammable materials.				- Where chemical use occurs (e.g. janitor and copying rooms), provide segregated areas with separate outside exhaust and maintain a negative pressure.										
					- Provide drains plumbed for appropriate disposal of liquid waste in spaces										

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
					where water and chemical mixing occurs.										
					- provide containment for disposal of hazardous liquid wastes in places where water and chemical mixing occurs.										
Material/Product Inputs		90.0	9.00%	Materials and Resources		12.0	10.91%	Stewarding Materials		22.0	12.29%	Materials credits		11.08	9.55%
A.2	**Environmental purchasing (incl. energy efficient prod.)**	**10**	**11.11%**					**SM-5**	**Modular Flooring Systems**	**1**	**4.55%**	**Wst5**	**Floor Finishes**	**0.64**	**5.78%**
	Apply environmental purchasing criteria or incorporate aspects of green specifications such as the EPA Comprehensive Procurement Guidelines and/or Green Spec®	3.0	**3.33%**										Where carpets and other floor finishes are specified by the future occupant or, in tenant areas of speculative buildings, where carpets or floor finishes are installed in a limited show area only.		
	Specify energy-saving, high-efficiency equipment based on Energy Star and/or the Reference Specifications for Energy and Resources Efficiency.	7.0	7.78%		(EA-1 - Strategies => performance based, no points allocated for including the technology)	0	0.00%								
E.1	**Low impact systems and materials -** Select materials that reflect the results of a "best run" life cycle assessment for the following:	**35**	**38.89%**					**SM-1**	**Non-Polluting Materials**	**3**	**13.64%**	**Mat 5**	**Responsible Sourcing of Materials**	**3.48**	**31.41%**
	- foundation and floor assembly and materials	10.0	**11.11%**										Where 80% of the metals, concrete, glass and stone in the following building elements are responsibly sourced: a. Roof b. Frame c. Walls (external) d. Floors (ground, upper) e. Foundations/substructure f. Doors g. Windows Additionally 100% of any timber must be certified to come from sustainable sources.		
	- column and beam or post and beam combinations, and walls	10.0	11.11%												
	- roof assemblies	10.0	11.11%												
	- Other envelope assembly materials (cladding, windows etc.)	5.0	5.56%												
E.	**Minimal**	**15**	**16.67**	**MR-**	**Material Reuse**	**2**	**16.67**	**SM**	**Material**	**1**	**4.55**	**Mat**	**Reuse of**	**0.8**	**7.85**

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100 %	BREEAM Gulf		116.0	100 %
2	**consumption of resources**		**%**	**3**			**%**	**-8**	**Reuse**		**%**	**3**	**Building Façade**	**7**	**%**
	- Specify used building materials and components.	3.0	**3.33%**	MR-3.1	Materials reuse, 5%	1	**8.33%**	**SM-2**	**Design for Materials Reduction**	**1**	**4.55 %**		Where evidence provided demonstrates that at least 50% of the total final façade (by area) is reused in situ and at least 80% of the reused façade (by mass) comprises in-situ reused material.		
					Specify salvaged or refurbished materials for 5% of building materials										
				MR-3.2	Materials reuse, 10%	2	**16.67 %**								
					Specify salvaged or refurbished materials for 10% of building materials										
	- Specify materials with recycled content.	3.0	**3.33%**	**MR-4**	**Recycled content**	**2**	**16.67 %**	**SM-10**	**Recycled Materials**	**6**	**27.27 %**				
				MR-4.1	Recycled content, 10% (post-consumer + ½ pre-consumer)	1	**8.33%**								
					Specify materials with recycled content such that the sum of post-consumer recycled content plus ½ of the post industrial content constitutes at least 10% of the total value of the materials of the project.										
				MR-4.2	Recycled content, 20% (post-consumer + ½ pre-consumer)	2	**16.67 %**								
					Specify materials with recycled content such that the sum of post-consumer recycled content plus ½ of the post industrial content constitutes at least 20% of the total value of the materials of the project.										
	- Specify materials from renewable sources that have been selected based on a life-cycle assessment (LCA).	3.0	**3.33%**	**MR-6**	**Rapidly renewable materials**	**1**	**8.33%**	**SM-11**	**Rapidly Renewable Materials**	**1**	**4.55 %**				
					Specify rapidly renewable building materials for 5% of total building materials.										
	- Specify locally manufactured materials that have been based on a LCA. Selected	3.0	**3.33%**	**MR-5**	**Regional materials**	**2**	**16.67 %**	**SM-9**	**Regional Materials**	**2**	**9.09 %**				
				MR-5.1	Regional materials, 10%	1	**8.33%**								
					Specify materials extracted, processed and manufactured within a 500 mi radius for 10% of the building material										
				MR-5.2	Regional materials,20%	2	**16.67 %**								
					Specify materials extracted, processed and manufactured										

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
					within a 500 mi radius for 20% of the building material										
	- Use lumber and timber panel products which originate from certified and sustainable sources - certified by SFI, FSC, ATFS, CSA International Standard. Avoid tropical hard works, unless certified.	3.0	**3.33%**	**MR-7**	**Certified wood**	**1**	**8.33%**	**SM-12**	**Reused or Certified Timber**	**2**	**9.09%**	**Mat 1**	**Materials Specification**	**4.35**	**39.26%**
					Use a minimum of 50% of wood-based materials and products, which are certified in accordance with the Forest Stewardship Council's (FSC) Principles and Criteria, for wood building components.								Where evidence provided demonstrates that the major building elements specified have an 'A rating', as defined in the Green Guide to Specification.		
E-3	**Reuse of existing buildings** (select ONE among 3.1 / 3.2 / 3.3, if applicable)	**15**	**16.67%**	**MR-1**	**Building reuse**	**4**	**33.33%**	**SM-7**	**Building Reuse**	**2**	**9.09%**	**Mat 4**	**Reuse of Building Structure**	**0.87**	**7.85%**
													Where evidence provided demonstrates that a design reuses at least 80% of an existing primary structure and, for part refurbishment and part new build, the volume of the reused structure comprises at least 50% of the final structure's volume.		
				MR-1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	3	**25.00%**								
	Retain at least 50% of existing facades in fully renovated buildings.	5.0	**5.56%**		Reuse 55%	1	**8.33%**								
	Retain at least 75% of existing facades in fully renovated buildings.	8.0	**8.89%**		Reuse 75%	2	**16.67%**								
	Retain at least 100% of existing facades in fully renovated buildings.	1.0	**1.11%**		Reuse 95%	3	**25.00%**								
	Retain a minimum 50% of the existing major structures (other than the shell i.e. walls, floors and ceilings)	5.0	**5.56%**	MR-1.2	Building reuse, maintain 50% of interior non-structural elements	1	**8.33%**								

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
E-4	**Building durability, adaptability and disassembly**	**15**	**16.67%**						**Building durability, adaptability and disassembly**			**Mat 7**	**Designing for Robustness**	**0.87**	**7.85%**
	Specify durable and low-maintenance building materials and assemblies that can withstand the following: sunlight, temperature and humidity changes, condensation, and war-and-tear associated with the amount and type of traffic expected.	5.0	5.56%					SM-6	Design for Durability	1	4.55%		Where protection is given to vulnerable parts of the building such as areas exposed to high pedestrian traffic, vehicular and trolley movements.		
	Implement a building design that promotes building adaptability.	5.0	5.56%					SM-3	Design for Flexibility & Adaptability	1	4.55%				
	Specify fastening systems that allow for easy disassembly.	5.0	5.56%					SM-4	Design for Disassembly	1	4.55%				
Indoor air quality & occupant comfort		**200.0**	**20.00%**	**Indoor Environmental Quality**		**14.0**	**12.73%**	**Livable Buildings : Indoors**		**20.0**	**11.17%**	**Health and Wellbeing**		**16.11**	**13.89%**
G.1	**Ventilation system**	**55**	**27.50%**	**EQP R-1**	**Minimum IAQ Performance**	**0**	**0.00%**	**LBi-R1**	**Healthy Ventilation Delivery**	**0**	**0.00%**	**Hea20**	**Ventilation Rates**	**1.24**	**7.70%**
	Provide ventilation in accordance with ANSI/ASHRAE 62.1 - 2004	10.0	**5.00%**		Meet the minimum requirements of voluntary consensus standard ASHRAE Standard 62.1-2007, Ventilation for Acceptable Indoor Air Quality and approved Addenda using the Ventilation Rate Procedure.								Where evidence provided demonstrates that each occupied space within the development achieves recommended minimum fresh air rates.		
				EQ-2	**Increased Ventilation**	**1**	**7.14%**	**LBi-1**	**Ventilation Quality**	**3**	**15.00%**	**Hea8**	**Indoor Air Quality**	**1.24**	**7.70%**
					FOR MECHANICALLY VENTILATED SPACES Increase breathing zone outdoor air ventilation rates to all occupied spaces by at least 30% above the minimum rates required by ASHRAE Standard 62.1-								Where air intakes serving occupied areas avoid major sources of external pollution and recirculation of exhaust air.		

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
					2007.										
					FOR NATURALLY VENTILATED SPACES Design natural ventilation systems occupied spaces to meet the recommendations set forth in the Carbon Trust "Good Practice Guide 237" (1998).										
	Avoid entraining pollutants into the ventilation air path by:														
	- positioning air intakes and outlets at least 30 ft. apart, and inlets not downwind of outlets.	3.0	**1.50%**												
	- locating air intakes more than 60 ft. from major sources of pollution and at least the minimum recommended distances from lesser sources of pollution.	3.0	**1.50%**												
	- protecting air intake openings.	2.0	**1.00%**												
	- specifying a ventilation lining that will avoid the release of pollution and fibers into the ventilation air path.	2.0	**1.00%**												
	Verify that the ventilation system provides effective air exchange (that the outdoor air delivered to the space actually reaches the occupants).	10.0	**5.00%**												
	Monitor indoor air quality either with CO_2 monitoring or digital	10.0	**5.00%**	**EQ-1**	**Outdoor air delivery monitoring**	**1**	**7.14%**								
					Monitor carbon dioxide concentration within densely										

Green Globes V.0		100 0	100%	LEED V3 New construction		11 0	100%	ESTIDAMA Buildings		179 .0	100 %	BREEAM Gulf	116 .0	100 %
	electronic airflow monitoring.				occupied spaces and provide a direct outdoor airflow measurement, as defined by ASHRAE Standard 62.1-2007, in non-densely occupied spaces.									
	Provide mechanical ventilation systems that allow for the flushing-out of the building with 100% outside air at ambient temperatures above 32°F.	5.0	**2.50%**	**EQ-3.**	**Construction IAQ Management Plan**	**2**	**14.29 %**	**LB i-3**	**Constructio n Indoor Air Quality Manageme nt**	**2**	**10.00 %**			
				EQ-3.1	During construction	1	**7.14%**							
					During construction meet or exceed the recommended Control Measures of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) IAQ Guidelines For Occupied Buildings Under Construction, 2nd Edition 2007, ANSI/SMACNA 008-2008 (Chapter 3).									
					Protect stored on-site or installed absorptive materials from moisture damage.									
					Filtration media with a Minimum Efficiency Reporting Value (MERV) of 13 shall be used at each return air grille, as determined by ASHRAE 52 2-1999, Replace all filtration media immediately prior to occupancy.									
				EQ-3.2	Before occupancy	1	**7.14%**							
					OPTION 1 - Flush-Out: Prior to occupancy perform a building flush-out by supplying a total air volume of 14,000 cu.ft. of outdoor air per sq.ft. of floor area while maintaining an internal temperature of at least 60 degrees F and relative humidity no higher than 60% OR									
					OPTION 2 - Air Testing: Conduct baseline IAQ testing demonstrating that contaminant									

	Green Globes V.0	1000	100%		LEED V3 New construction	110	100%		ESTIDAMA Buildings	179.0	100%		BREEAM Gulf	116.0	100%
					maximum concentrations are not exceeded.										
	Provide mechanical ventilation of enclosed parking areas.	5.0	**2.50%**					**LBi-4**	**Car Park Air Quality Management**	**1**	**5.00%**				
	Specify personal control over the ventilation rates, either through operable windows, personalized HVAC controls or, in naturally ventilated buildings, trickle vents on all windows.	5.0	**2.50%**	**EQ-6.2**	**Controllability of systems, thermal comfort**	**1**	**7.14%**								
					Achieve compliance with ASHRAE Standard 62.1-2007 for thermal comfort.										
	Specify filters with a Minimum Efficiency Reporting Value (MERV) of 13 (80-90% atmospheric dust-spot efficiency) for air distributed to occupied spaces.	5.0	**2.50%**												
G.2	**Control of indoor pollutants**	**45**	**22.50%**	**EQ-4**	**Low-emitting materials**	**4**	**28.57%**								
	Implement design measures to prevent the growth of fungus, mold and bacteria on building surfaces and in concealed spaces.	10.0	5.00%												
	Ensure easy access to the air-handling units (AHUs), for regular inspection and maintenance.	5.0	2.50%												
	Design a humidification system that is designed to avoid the growth of microorganisms.	5.0	2.50%												
	Provide Carbon Monoxide (CO) monitoring in parking garages.	5.0	2.50%												

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
	Provide measures to mitigate pollution at source such as physical isolation of the spaces, separate ventilation, or a combination of isolation and ventilation for areas that generate contaminants.	5.0	2.50%												
	Design and locate wet cooling towers that are designed and located in such as way as to avoid the risk of Legionella.	5.0	2.50%												
	Design a domestic hot water system that is designed to reduce the risk of Legionella.	5.0	2.50%												
												Pol8	**Noise Attenuation**	**1.02**	**6.33%**
													Where evidence provided demonstrates that sources of noise from the development do not give rise to the likelihood of complaints from existing noise sensitive premises and amenity or wildlife areas that are within the locality of the site.		
	Use inferior materials, including paints, sealants, adhesives, carpets and composite wood products that are low-VOC emitting, non-toxic and chemically inert.	5.0	2.50%	EQ-4.1	Low-emitting materials, adhesives & sealants	1	**7.14%**	**LBi-2.1**	**Materials Emissions : Adhesives & Sealants**	**1**	**5.00%**	**Hea9**	**Volatile Organic Compounds**	**1.24**	**7.70%**
					Select adhesives and sealant that attain VOC content as specified in SCAQMD Rule #1168 select sealants used as fillers that meet the requirements specified in the Bay Area Quality Management District Regulation 8, Rule 51.								Where the design team has carried out a review of all finishes and fittings containing volatile organic compounds (VOCs).		
				EQ-4.2	Low-emitting materials, paints & coatings	1	**7.14%**	**LBi-2.2**	**Materials Emissions : Paints & Coatings**	**1**	**5.00%**				
					VOC emissions from paints and coatings must not exceed the VOC										

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
					and chemical component limits of SCAQMD's Standard requirements.										
				EQ-4.3	Low-emitting materials, Flooring systems	1	**7.14%**	**LBi-2.3**	**Materials Emissions: Carpet & Hard Flooring**	**1**	**5.00 %**				
					Option 1: • Carpet systems must or exceed the requirements of the Carpet and Rug Institute Green Label Indoor Air Quality Test Program. • Hard surface flooring must be Floor Score compliant or 100% of the non-carpet finished flooring must be Floor Score-certified and must constitute at least 25% of the finished floor area. • Concrete, wood, bamboo, and cork finishes must meet SCAQMD Rule 1113, Architectural Coatings, rules in effect on January 1, 2004. • Tile setting adhesives and grout must meet SCAQMD Rule 1168. VOC limits correspond to an effective date of July 1, 2005 and rule amendment date of January 7, 2005. Option 2: • All flooring elements installed in the building interior must meet the testing and product requirements of the California Department of Health Services Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda.										
				EQ-4.4	Low-emitting materials, composite wood & agrifiber products	1	**7.14%**	**LBi-2.4**	**Materials Emissions : Ceiling Systems**	**1**	**5.00 %**				
					Composite wood or agrifiber products must contain no added			**LBi-2.5**	**Materials Emissions : Formaldehyde**	**2**	**10.00 %**				

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
					urea-formaldehyde resins.				**Reduction**						
G. 3	**Lighting**	**50**	**25.00%**	**EQ-8**	**Daylight and views**	**2**	**14.29%**								
	Day lighting	10	**5.00%**	EQ-8.1	Daylight 75% of Spaces	1	**7.14%**	**LBi-7**	**Daylight & Glare**	**2**	**10.00%**	**Hea1**	**Day lighting**	**1.24**	**7.70%**
	Provide ambient daylight to 80% of the primary spaces.	5.0	**2.50%**		Achieve a minimum Daylight Factor of 2% (excluding all direct sunlight penetration) in 75% of all space occupied for critical visual tasks, not low occupancy support areas.								Where at least 80% of floor area in occupied spaces is adequately day lit.		
	Achieve minimum daylight factor of 0.2 for work places of living/dining areas that require moderate lighting, and 0.5 for work areas requiring good lighting.	5.0	**2.50%**									**Hea3**	**Glare Control**	**1.24**	**7.70%**
													Where evidence provided demonstrates that: 1. An occupant controlled glare control system (e.g. internal or external blinds) is fitted to all areas where computer workstations will be located or close work will be undertaken. 2. Glare to other occupied areas has been minimized through specification and design whilst maintaining sufficient natural daylight and avoiding the need for artificial light.		
	Views	10	**5.00%**	EQ-8.2	Views for 90% 0f Spaces	1	**7.14%**	**LBi-8**	**Views**	**1**	**5.00%**	**Hea2**	**View Out**	**1.24**	**7.70%**
	Provide views to the building exterior or to atria from all primary interior spaces.	5.0	**2.50%**		Direct line of sight to vision glazing from 90% of all regularly occupied spaces, not low occupancy support areas.								Where evidence provided demonstrates that all workstations/desks are within a 7m radius of a window.		
	Specify solar shading devices to enable occupants to control brightness from day lighting.	5.0	**2.50%**												
	Lighting Design	30	**15.00%**	**EQ-6.1**	**Controllability of systems, lighting**	**1**	7.14%	**LBi-6**	**High Frequency Lighting**	**1**	**5.00%**	**Hea4**	**High Frequency Lighting**	**1.24**	**7.70%**
	Specify lighting controls that relate to room occupancy, circulation space, day lighting and the number of workstations in office areas.	10.0	**5.00%**		Provide individual lighting controls for 90% (minimum) of the building occupants to enable adjustments to suit individual task needs and preferences.								Where evidence provided demonstrates that high frequency ballasts are installed on all fluorescent and compact fluorescent lamps.		
					Provide lighting system controllability for all shared multi-occupant spaces to enable lighting adjustments that meets group										

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100 %	BREEAM Gulf		116.0	100 %
					needs and preferences.										
	Provide light levels no less than those recommended in IESNA Lighting Handbook, 2000, for the types of tasks that are anticipated in the various building spaces (regardless of day lighting).	10.0	**5.00%**									**Hea5**	**Internal & External Lighting Levels**	**1.24**	**7.70 %**
	Avoid excessive direct or reflected glare, as per IENSA RP-5, 1999, Recommended Practice of Day lighting.	10.0	**5.00%**										Where evidence provided demonstrates that all internal and external lighting, where relevant, is specified in accordance with the appropriate maintained luminance levels (in lux) recommended by CIBSE or IESNA.		
G.4	**Thermal comfort**	**20**	**10.00 %**	**EQ-7**	**Thermal comfort**	**2**	**14.29 %**	**LBi-5**	**Thermal comfort**		**25.00 %**	**Hea10**	**Thermal Comfort**	**1.24**	**7.70 %**
	Achieve Compliance with ASHRAE 55 - 2004 for thermal comfort.	20.0	**10.00 %**	EQ-7.1	Thermal comfort, design	1	**7.14%**	LBi-5.1	Thermal Comfort & Controls: Thermal Zoning	**1**	**5.00 %**		Where thermal comfort levels are assessed at design stage, this is used to evaluate appropriate servicing options, and appropriate thermal comfort levels are achieved.		
					Design HVAC systems and the building envelope to meet the requirements of ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy.			LBi-5.2	Thermal Comfort & Controls: Occupant Control	**2**	**10.00 %**	**Hea11**	**Thermal Zoning**	**1.24**	**7.70 %**
				EQ-7.2	Thermal comfort, verification	1	**7.14%**	LBi-5.3	Thermal Comfort & Controls: Thermal Comfort Modeling	**2**	**10.00 %**		Where evidence provided demonstrates that local occupant control is available for temperature adjustment in each area to reflect differing load requirements.		
					Agree to implement a thermal comfort survey of building occupants within a period of six to 18 months after occupancy. Agree to develop a plan for corrective action if more than 20% of occupants are dissatisfied with thermal comfort.										

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
G.5	**Acoustic comfort**	**30**	**15.00%**					**LBi-9**	**Indoor Noise Pollution**	**1**	**5.00%**	**Hea13**	**Acoustic Performance - Internal Noise Levels**	**1.24**	**7.70%**
	Site the building location and zone spaces within the building to provide optimum protection from undesirable outside noise.	5.0	**2.50%**										Where evidence provided demonstrates that the building design can be shown to achieve indoor ambient noise levels in unoccupied spaces in accordance with BS8233:1999.		
	Specify an appropriate sound transmission class rating of perimeter walls in response to external noise levels.	5.0	**2.50%**									**Tra9**	**Home Office**	**0.21**	**1.30%**
	Provide noise attenuation of the structural systems, and measures to insulate primary spaces from impact noise.	5.0	**2.50%**										For the provision of a space and services which allows the occupants to set up a home office in a quiet room.		
	Specify acoustic controls to meet the acoustic privacy requirements.	5.0	**2.50%**												
	Specify measures to meet speech intelligibility requirements for the various spaces and activities.	5.0	**2.50%**												
	Mitigate acoustic problems associated with mechanical equipment and plumbing system noise and vibration.	5.0	**2.50%**												
				EQP R-2	**Environmental tobacco smoke control**	**0**	**0.00%**	**LBi-R2**	**Smoking Control**	**0**	**0.00%**	**Hea21**	**Smoking Ban**	**1.24**	**7.70%**
					Zero exposure of non-smokers to ETS by prohibition of smoking in the building, OR, provide a designated smoking room designed to effectively contain, capture								Where evidence provided demonstrates that each occupied space within the development achieves recommended minimum fresh air rates.		

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100 %	BREEAM Gulf		116.0	100 %
					and remove ETS from building.										
Transport		**80.0**	**8.00%**	**Sustainable Sites**		**12.0**	**10.91 %**	**Livable Buildings : Outdoors**		**11.0**	**6.15 %**	**Transport credits**		**3.0**	**2.59 %**
C.5	**Energy efficient transportation**	**80**	**100.00 %**	**SS-4**	**Transportation**	**12**	**100.00 %**								
	Public Transport	60	**75.00 %**	SS-4.1	Alternative transportation, public transportation access	6	**50.00 %**	**LBo-6**	**Public Transport**	**3**	**27.27 %**	**Tra1**	**Provision of Public Transport**	**0.86**	**28.67 %**
	Provide access to public transport within 500 Yards of the building, with the services at least every 15 minutes during rush hour.	50.0	**62.50 %**		Locate buildings within 1/4 mile of commuter or light rail, subway station or 1/4 mile of 2 or more public or campus bus lines.								**1 half:** Where good access is available to and from public transport networks for commuting. **2 half:** Where there is good access to and from public transport networks for business travel.		
	Designated prefered parking for car/van pooling, and shelter at pick-up and drop-off locations.	6.0	**7.50%**	SS-4.4	Alternative transportation, parking capacity	2	**16.67 %**	**LBo-8**	**Preferred Car Parking Spaces**	**1**	**9.09 %**	**Tra6**	**Maximum Car Parking Capacity**	**0.43**	**14.33 %**
					Parking capacity to meet but not exceed local zoning requirements AND provide prefered parking for carpools.								Where evidence is provided to demonstrate that the number of parking spaces provided for the building has been limited.		
	Provide an alternative-fuel re-fuelling facilities on-site or in the general vicinty.	4.0	**5.00%**	SS-4.3	Alternative transportation, Low-emitting and Fuel-efficient Vehicles	3	**25.00 %**					**Tra8**	**Deliveries & Maneuvering**	**0.21**	**7.00 %**
					Provide alternative fuel vehicles for 3% of the building occupants AND provide preferred parking for these vehicles - OR install alternative-fuel vehicle refueling stations for 3% of the total vehicle parking capacity of the site.								Where evidence is provided to demonstrate that vehicle access areas have been designed to ensure adequate space for maneuvering delivery vehicles and provide space for storage of refuse skips and pallets.		
	Cyclic Facilities	20	**25.00 %**	SS-4.2	Alternative transportation, bicycle, storage & changing rooms	1	**8.33%**	**LBo-7**	**Bicycle Facilities**	**2**	**18.18 %**				
	Provide safe, covered storage areas with fixed mountings for securing bicycles.	10.0	**12.50 %**		For commercial/institutional buildings secure bicycle storage with changing/shower facilities (within 200 yards of the buildings) for more than 5% of building occupants.										
	Provide changing facilities or large washrooms for occupants to change from cycling wear to office-work	10.0	**12.50 %**												

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
	apparel.														
												Tra6	**Pedestrian Safety**	**0.21**	**7.00%**
													Where evidence provided demonstrates that pedestrian routes form a direct route on to and off the site.		
								LBo-1	**Improved Outdoor Thermal Comfort**	**2**	**18.18%**				
								LBo-3	**Accessible Community Facilities**	**1**	**9.09%**	**Tra3**	**Proximity to Amenities**	**0.43**	**14.33%**
								LBo-4	**Active Urban Environments**	**1**	**9.09%**		**1st half:** Where the site is within 500m of the following amenities: a. Post box b. Grocery shop **2nd half:** Where the site is within 1000m of at least 5 of the following amenities: a. Postal facility b. Grocery shop and/or food outlet c. Bank/cash point d. Pharmacy e. Doctors surgery/medical centre f. Community centre g. Leisure centre h. Open access public place i. Place of worship j. Primary school k. Children's play area		
								LBo-5	**Private Outdoor Space**	**n/a**					
								LBo-9	**Travel Plan**	**1**	**9.09%**	**Tra5**	**Travel Plan & Remote Conferencing**	**0.43**	**14.33%**
													1 half: Where evidence is provided to demonstrate that a travel plan has been developed and tailored to the specific needs of the staff and visitors using the building. **2 half:** Where, in addition to the above, a delivery policy has been developed and tailored to minimize the impacts of deliveries of supplies/equipment to the building.		
												Tra7	**Travel Information point**	**0.43**	**14.33%**
													Where evidence is provided to demonstrate that there is a dedicated space within the		

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
													development for the provision of up-to-date public transport information.		
Site ecology		115.0	11.50%	Sustainable Sites		13.0	11.82%	Natural Systems		16.0	8.94%	Land Use and Ecology Credits		12.68	10.93%
B.1	**Development areas (site selection, development density, site remediation)**	**30**	**26.09%**	**SS-1**	**Site selection**	**1**	**7.69%**	**NS-R1**	**Natural Systems Assessment**	**0**	**0.00%**	**LE9**	**Site appraisal**	**0.90**	**7.10%**
	Demonstration on the site plan how any portions of the site identified as being a wetland or wildlife corridor, agricultural land, parkland, or an area notable for its scenic beauty, will be fully preserved. Carry out all required environmental assessments.	10.0	**8.70%**		Do not develop buildings on portions of sites that meet any one of the following criteria: Prime farmland, habitat for any species on Federal or State threatened or endangered list, land within 100 ft of water (including wetlands), public parkland.								Where evidence provided demonstrates that the design team has carried out a detailed site investigation and taken this and the presence of sensitive environmental receptors into account in site selection and development layout.		
	Building SITE Criteria (choose ONE of the 3 below):	15.0	**13.04%**												
	Select an existing serviced site.														
	Existing minimum development density of 60,000 ft^2/acre.			**SS-2**	**Development density & community connectivity**	**5**	**38.46%**	**LBo-R1**	**Plan 2030**	**0**	**0.00%**				
					Increase localized density by utilizing sites that are located within an existing minimum development density of 60,000 square feet per acre (2 story downtown development).			**LBo-2**	**Pearl Rated Communities**	**1**	**6.25%**				
	Remediated, previously contaminated site.			**SS-3**	(Brownfield redevelopment => see below)			**NS-2**	**Remediation of Contaminated Land (see below)**	**2**	**12.50%**	**LE1**	**Reuse of Land / Contaminated Land**	**0.90**	**7.10%**
													Where evidence is provided to demonstrate that the majority of the footprint of the proposed development falls within the boundary of previously developed land. OR Where evidence is		

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100 %	BREEAM Gulf		116.0	100 %
													provided to demonstrate that the land used for the new development has, prior to development, been defined as contaminated and adequate remedial steps have been taken to decontaminate the site prior to construction		
				SS-5.2	**Site development, maximize open space**	**1**	**7.69%**	**LBo-R2**	**Urban Systems Assessment**	**0**	**0.00 %**	**LE3**	**Ecological Value of Land & Protection of Ecological Features**	**0.90**	**7.10 %**
					Reduce development footprint (including building, access roads and parking) to exceed the local zoning's open space requirement for the site by 25%.								Where evidence provided demonstrates that the site's construction zone is defined as land of low ecological value and all existing features of ecological value will be fully protected from damage during site preparation and construction works.		
								NS-R2	**Natural Systems Protection**	**0**	**0.00 %**	**LE6**	**Long term impact on biodiversity**	**0.90**	**7.10 %**
													Where evidence is provided to demonstrate that the site has been designed to minimize the long term impact of the development on the site's, and surrounding area's biodiversity.		
	Minimize the disturbance of undeveloped areas of the site. Minimize the area of the site for the building, parking, and access roads, and locate new building on previously disturbed parts of the site. Preserve significant trees and natural slopes to maintain the existing direction of groundwater flow. Map all the exiting site vegetation.	5.0	**4.35%**	**SS-5.1**	**Site development, protect or restore habitat**	**1**	**7.69%**	**NS-4**	**Habitat Creation & Restoration**	**6**	**37.50 %**	**LE4**	**Impact on Site Ecology**	**4.51**	**35.57 %**
					On Greenfield sites, limit site disturbance including earthwork and clearing of vegetation to 40 feet beyond the building perimeter, 5 feet beyond primary roadway curbs, walkways, and main utility branch trenches, and 25 feet beyond of pervious paving areas that require additional staging areas in order to limit compaction in the paved area; or, on previously developed sites, restore a minimum of 50% of the remaining open area by								**1/5:** Where evidence is provided to demonstrate that the design team (or client) has appointed a Suitably Qualified Ecologist to advice and report on enhancing and protecting the ecological value of the site. **2/5:** Where evidence is provided to demonstrate that the residual impact of the development is zero, i.e. a negative change in the short to medium term, but no predicted net loss in conservation status in the long-		

Green Globes V.0		1000	100%		LEED V3 New construction		110	100%		ESTIDAMA Buildings		179.0	100%		BREEAM Gulf		116.0	100%
						planting native or adapted vegetation.										term, 0 points scored using LE4 Calculator. **3/5**: Where evidence is provided to demonstrate that the residual impact of the development is a negative change in the short to medium term, but a predicted minor net gain in conservation status in the long-term, 1 or 2 points scored using LE4 Calculator. **4/5**: Where evidence is provided to demonstrate that the residual impact of the development is a small negative change in the short to medium term, but a predicted medium net gain in conservation status in the long-term, 3 points scored using LE4 Calculator. **5/5:** Where evidence is provided to demonstrate that the residual impact of the development is a small negative change in the short to medium term, but a predicted major gain in the long-term, >3 points scored using LE4 Calculator		
B. 2	**Ecological impacts**	**30**	**26.09 %**		**SSPR -1**	**Construction activity pollution prevention**	**0**	**0.00%**		**NS -R3**	**Natural Systems Design & Management Strategy**	**0**	**0.00 %**		**Man 3**	**Construction Site Impacts**	**2.53**	**19.95 %**

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
	Provide a drainage and erosion/sediment control plan that includes measures such as limiting grading, leaving steeper slopes undisturbed, avoiding soil compaction, and protecting vegetative ground cover. Include measures for the construction stage.	9.0	**7.83%**		Create and implement an Erosion and Sedimentation Control (ESC) Plan for all construction activities associated with the project.								**1/4:** Where evidence provided demonstrates that 2 or more of items a-g (listed below) are achieved. **2/4:** Where evidence provided demonstrates that 4 or more of items a-g (listed below) are achieved. **3/4:** Where evidence provided demonstrates that 6 or more of items a-g are achieved: a. Monitor, report and set targets for CO_2 or energy arising from site activities b. Monitor, report and set targets for CO_2 or energy arising from transport to and from site c. Monitor, report and set targets for water consumption arising from site activities d. Implement best practice policies in respect of air (dust) pollution arising from the site e. Implement best practice policies in respect of water (ground and surface) pollution occurring on the site f. Main contractor has an environmental materials policy, used for sourcing of construction materials to be utilised on site g. Main contractor operates an Environmental Management System. **4/4:** Where evidence provided demonstrates that at least 80% of site timber is responsibly sourced and 100% is legally sourced.		
				SS-7	**Heat island effect**	**2**	**15.38 %**								
	Provide natural cover including trees that within 5 years will shade at least 30% of impermeable surfaces. At minimum there should one tree for every 100 ft^2	7.0	**6.09%**	SS-7.1	Heat island effect, non-roof	1	**7.69%**	**LBo-R3**	**Outdoor Thermal Comfort Strategy**	**0**	**0.00 %**				
					Provide shade (within 5 years) on at least 30% of non-roof impervious surface on the site, including parking lot, walkways, plazas, etc., OR, use light										

Green Globes V.0		100 0	100%	LEED V3 New construction		11 0	100%	ESTIDAMA Buildings		179 .0	100 %	BREEAM Gulf		116 .0	100 %
	of impermeable surface including parking, walkways and plazas. Where natural shading is not possible, install artificial shading such as covered walks, or light-colored, high-albedo materials (reflectance of at least 0.3) over the site's impervious surfaces.				colored/high-albedo materials (reflectance of at least 0.3) for 30% of the site's non-roof impervious surfaces, OR place a minimum of 50% of parking space underground OR use open-grid pavement system (net impervious area of LESS than 50%) for a minimum of 50% of the parking lot area.										
	Specify measures to reduce heat build-up on the roof (either high-albedo roofing materials - reflectance of at least 0.65 and emissivity of at least 0.9 for a minimum of 75% of the roof surface - OR a green roof, OR a combination of both).	7.0	**6.09%**	SS-7.2	Heat island effect, roof	1	**7.69%**	**LBo-1**	**Improved Outdoor Thermal Comfort**	**2**	**12.50 %**				
					Use ENERGY STAR® complaint (high-reflectance) AND high emmisivity roofing (at least 0.9 when tested in accordance with ASTM 408) for a minimum of 75% of the roof surface; OR, install a "green" (vegetated) roof for at least 50% of the roof area. Combination of high albedo and vegetated roof can be used providing they collectively cover 75% of the roof area.										
	Minimize the obtrusive aspects of exterior lighting (e.g. glare, light trespass and sky glow) as per the optical design recommendations of the Illuminating Engineering Society of North America (IESNA), such that no lights is emitted above a horizontal plane passing through the bottom of the fixture; and less than	7.0	**6.09%**	**SS-8**	**Light pollution reduction**	**1**	**7.69%**	**LBo-10**	**Light Pollution Reduction**	**1**	**6.25 %**	**Pol7**	**Reduction of Night Time Light Pollution**	**1.02**	**8.04 %**
					Do not exceed illuminating Engineering Society of North America (IESNA) foot-candle level requirements as stated in the ASHRAE/IESNA Standard 90.1-2007 such that zero direct-beam illumination leaves the building site.								Where evidence provided demonstrates that the external lighting design is in compliance with the guidance in the Institution of Lighting Engineers (ILE) Guidance notes for the reduction of obtrusive light, 2005.		

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
	10% of the emitted light shines within 10 degrees below the horizontal plane passing through the bottom of the fixture.														
B.3	**Watershed features (site grading, stormwater management, previous cover, rainwater capture)**	**20**	**17.39 %**	**SS-6.1**	**Stormwater design, quantity control**	**1**	**7.69%**	**PW-4**	**Stormwater Management (see above)**			**Pol5**	**Sustainable Urban Drainage Systems**	**1.02**	**8.04 %**
	Provide a stormwater management plan to prevent damage to project elements, including vegetation, on both the project site and those adjacent to it. Include an engineering design of the site drainage pattern including volume calculations and site management strategies. Aim for no increase in run-off. OR, if the site already consists of more than 50% impervious surface in its pre-development state, aim for a reduction of 25% in stormwater run-off.	10.0	**8.70%**		Implement a stormwater management plan that results in no net increase in the rate or quantity of stormwater runoff from existing to developed conditions; OR, if existing imperviousness is greater than 50%, implement a stormwater management plan that results in a 25% decrease in the rate or quantity of stormwater runoff.								Where evidence provided demonstrates that surface water run-off attenuation measures are specified to minimise the risk of localised flooding, resulting from a loss of flood storage on site due to development.		
	Provide measures to control run-off from the roof and direct it to a previous area, or a green roof.	10.0	**8.70%**												
B.4	**Site ecology enhancement**	**35**	**30.43 %**	**SS-5.1**	**(Site development, protect or restore habitat - see above)**			**NS-3**	**Ecological Enhancement**	**2**	**12.50 %**				
	Specify a naturalized landscape usingnative trees, shrubs	10.0	**8.70%**												

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100%	BREEAM Gulf		116.0	100%
	and ground cover, with minimal lawn.														
	Create a biophysical inventory of on-site plants to be retained or salvaged and re-planted.	10.0	**8.70%**												
	Remediate a brownfield site.	15.0		**SS-3**	**Brownfield redevelopment**	**1**	**7.69%**	**NS-2**	**Remediation of Contaminated Land (see above)**						
					Develop a site that is documented as contaminated (by means of an ASTM E1903-97 Phase II Environmental Site Assessment) OR a site designated a Brownfield by authorities with jurisdiction. Effectively remediate site contamination.										
								NS-1	**Reuse of Land**	**2**	**12.50%**				
Other sustainable systems & processes		**40.0**	**4.00%**	**Innovation and Design Process**		**12.0**	**10.91%**	**Integrated Development Process**		**16.0**	**8.94%**	**Management**		**6.75**	**5.82%**
				ID-2	**LEED accredited professional**	**1**	**8.33%**								
A.3	**Commissioning**	**15**	**37.50%**	**EAPR-1**	**Fundamental commission of the building energy systems**	**0**	**0.00%**	**IDP-R3**	**Basic Commissioning**	**0**	**0.00%**	**Man 1**	**Commissioning**	**1.69**	**25.04%**
	Engage an independent Commissioning Authority.	3.0	**7.50%**		Engage a commissioning team not affiliated with the design/delievery team. Team will review design documentation, verify installation, functional performance, training operation, and maintenance documentation and complete commissioning report.								**1st half:** Where evidence provided demonstrates that an appropriate project team member has been appointed to monitor commissioning on behalf of the client to ensure commissioning will be carried out in line with current best practice. **2nd half**: Where evidence provided demonstrates that seasonal commissioning will be carried out during the first year of occupation, post construction (or post fit out).		
	Provide "Design Internet" and "Basis of Design" documentati	3.0	**7.50%**	**EA-3**	**Enhanced commissioning**	**2**	**16.67%**	**IDP-5**	**Re-Commissioning**	**2**	**12.50%**				

Green Globes V.0		1000	100%	LEED V3 New construction		110	100%	ESTIDAMA Buildings		179.0	100 %	BREEAM Gulf		116.0	100 %
	on.														
	Include commissioning requirements in the Construction Documentation.	3.0	**7.50%**		Hire a secondary independent commissioning authority in addition to the Fundamental Building Commissioning prerequisite.										
	Develop a Commissioning Plan.	6.0	**15.00 %**												
A-4	**Emergency response plan**	**5**	**12.50 %**					**LBi-10**	**Safe & Secure Environment**	**1**	**6.25 %**				
	Include the project's enviromental goals and procedures with regard to emergency response in Division 1 of the specifications.	5.0	**12.50 %**												
				ID-1.1 to 1.4	**Innovation design**	**5**	**41.67 %**	**IP-1**	**Innovative Cultural & Regional Practices**	**1**	**6.25 %**	**Man 2**	**Considerate Constructors**	**1.69**	**25.04 %**
					Substantially exceed a LEED-NC performance credit such as energy performance of water efficiency. Apply strategies or measures that demonstrate a comprehensive approach and quantifiable environment and/or health benefits.			**IP-2**	**Innovating Practice**	**2**	**12.50 %**		**1st half:** Where evidence provided demonstrates that there is a commitment to comply with best practice site management principles. **2nd half:** Where evidence provided demonstrates that there is a commitment to go beyond best practice site management principles.		
A-1	**Integrated design process**	**20**	**50.00 %**					**IDP-R1**	**Integrated Development Strategy**	**0**	**0.00 %**				
	Use an integrated design process for the design development to identify functional and environmental priorities at the initiation of the project, evaluate options, and develop the design.	10.0	**25.00 %**												
	Solicit input from all members of the design team at each stage of the design process.	5.0	**12.50 %**												
	Use green design facilitation	5.0	**12.50 %**												

Green Globes V.0		1000	100%
	to support the integrated design process and involve team members throughout each stage of project delievery.		

LEED V3 New construction	110	100%

ESTIDAMA Buildings		179.0	100 %
ID P-R2	**Tenant Fit-Out Design & Construction Guide**	0	0.00 %
ID P-1	**Life Cycle Costing**	4	25.00 %
ID P-2	**Guest Worker Accommodation**	2	12.50 %
ID P-3	**Construction Environmental Management**	2	12.50 %
ID P-6	**Sustainability Communication**	2	12.50 %

BREEAM Gulf		116.0	100 %
Man 4	**Building User Guide**	0.84	12.44 %
	Where evidence provided demonstrates the provision of a simple guide that covers information relevant to the tenant/occupants and non-technical building manager on the operation and environmental performance of the building.		
Man 12	**Whole Life Costing**	1.69	25.04 %
	1st half: Where evidence provided demonstrates that an assessment of Whole Life Costing has been undertaken on the building design at a strategic level (see Additional information) **2nd half:** Where evidence provided demonstrates that an assessment of Whole Life Costing has been, or will be, undertaken on the building design at a a. Strategic level. b. Component level		
Man 11	**Ease of Maintenance**	0.84	12.44 %
	Where evidence provided demonstrates that specifications for the building and the building services/systems and landscaping have considered ease and efficiency of		

Green Globes V.0	1000	100%		LEED V3 New construction		110	100%		ESTIDAMA Buildings	179.0	100%		BREEAM Gulf		116.0	100%
														maintenance in line with best practice.		
				RP-1.1 to 1.4	**Regional Priority: Specific Credit**	**4**	**33.33 %**									