METHODOLOGY TO ASSESS THE COST-EFFECTIVENESS OF SUSTAINABLE MEASURES IN BUILDINGS

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Summary

Many recognize the value of sustainable construction as it reduces the negative impact on the environment and improves quality, accessibility and productivity for all of those who live and work inside buildings. However, economical advantages, which would help expand the concept in the marketplace, have not yet been established. The objective of this paper is to present a methodology to assess the cost-effectiveness of the application of sustainable measures in buildings through actions that establish a balance between environmental, economical and social factors. The methodology is based on the comparison of a case study (a building in which sustainable concepts were applied) with reference buildings making it possible to demonstrate triple bottom line added values. The aim is to achieve an optimum balance point, with an acceptable pay-back time and to provide evidence of good economic results in order to encourage the investment on sustainable construction.

1. Introduction

This paper was prepared with the objective of highlighting the concept of sustainable measures in building construction, a concept which has been commonly rejected for one main reason, its cost effectiveness. This problem is linked to some key issues:

- The lack of financial support, direct incentives and understanding of different advantages associated to sustainable buildings by governments, financial institutions and insurance companies.
- Builders and promoters in the real estate market have maintained a basic behaviour (and interest) to look for standard solutions that avoid an increase in the initial cost (investment) of new projects (construction phase). Thus they are transferring operational costs associated to the life cycle of the building to future owners.
- Finally, it is commonplace to observe the general conduct (building stakeholders) that is characterized by a restricted ability to consider the real costs generated during construction and operational phases in buildings. These costs are not considered or introduced in the market price formula, nor are they considered in the planning phase. Simply, they do not exist for building stakeholders. Some of these costs include: wastes, diseases and emissions (pollutants or CO2).

For this reason some countries have been trying to develop different tools for economical and financial feasibility as well as promote financial support, through incentives and subsidies that encourage the public and private investment onto Sustainable construction. These are recognized by their demand-efficiency in energy (25 to 30%) and water, less volume of construction residues and the use of durable materials (Kats, Gregory, 2003).

2. Tools to assess sustainable construction

Different countries have been developing studies and financial tools with the main purpose of implementing Sustainable Construction and disseminating a new mentality into the marketplace. Many of these studies are based on tools to assess sustainability which are divulged in a country and tailored to its reality, such as LEED (Leadership in Energy and Environmental Design) in the USA, Breeam (Building Research Establishment's Environmental Assessment Method) in the UK, Casbee (Comprehensive Assessment System for Building Environmental Efficiency) in Japan, among others.

Defined by a methodology and an evaluation system, these tools aim to classify and recognize a sustainable building, and at the same time, they work as a guideline for builders and project designers. A well-known example is the research carried out in the United States, where 33 buildings were compared (certified buildings or in the certification process, by LEED) with other conventional buildings. In this analysis, certain assumptions were used such as discount rates -5%; period of analysis - 20 years; annual inflation - 2%.

It was observed in " The costs and financial benefits of Green Buildings" report (Kats, Gregory 2003), that an investment of 2% (on average) over the initial cost (compared to a conventional building), produces financial benefits 10 times higher than the referred investment (for a period of 20 years), considering the analysis of some cost categories, such as consumptions, maintenance, emissions and productivity.

The same report gives us a simple example of how to evidence these benefits. Applied to a real case and assuming that the construction costs in California are about $150/ft2 to $250/ft2, increasing 2% to these values, it would be equal to $3/ft2 and $5/ft2, respectively. The cost effectiveness analyzed in 20 years would be equal to $48/ft2 and $75/ft2. If these values did not include the inherent benefits concerning CO_2 emissions and productivity (just considering the reduction of energy and water demand, and less volume of waste) these would be around $6/ft2 (Kats, Gregory, 2003).

Another interesting study (also in the United States), prepared by David Langdon (2004), had the objective of analyzing costs linked to the construction phase of a "green building". This study showed that these costs (construction phase) drive the main decisions in sustainable projects (see figure 1). This report, which compared the construction cost per area in certified and non certified buildings by LEED, accounted for the cost of an information "database" of more than 600 projects (from 19 different States, typologies, locations, sizes and programs).

The referred study concluded that many projects reached the sustainability with their initial budgets or with a minimal additional increase (on average 2%).

In Europe, there are new incentives and legislation seeking to promote more aggressive policies in relation to the challenges of sustainable buildings. New studies have been carried out dedicated to cost effective buildings through sustainable construction concepts. These studies have been financed by the European Commission. Examples are the ASCOT model (Assessment of Sustainable Construction and Technologies Cost), a project carried out in 2004 by HQE2R and Cenergia. This tool helps users to implement a cost optimization of construction in which sustainability measures have been applied.

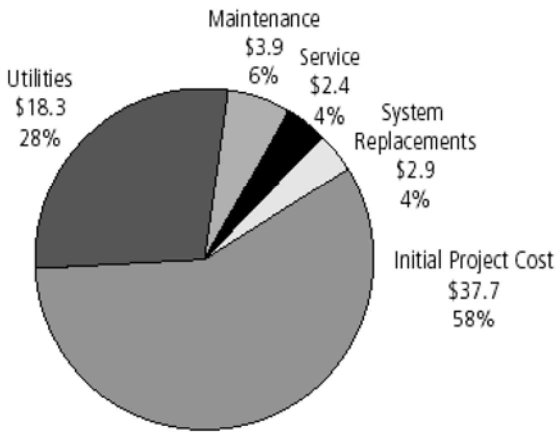

Figure 1 30 years Life Cycle Cost - Building example (Megan, Davis et. al, 2005)

There was also an increased interest in the subject of economic feasibility related to assessment tools and projects which can be applied to sustainable construction, such as SHE (Sustainable Housing in Europe): SHE has the main function of helping in the concept, cost analysis (initial cost and comparison to new buildings) and different options to obtain a higher viability of sustainable measures in projects. Another project, also co-financed by the European Commission, is the LCC-IP –"Guidebook-Integrated Planning for Building Refurbishment Taking Life- Cycle-Cost into Account". This project was constituted by several European case studies where an optimized relation between sustainable measures and cost – benefit analysis was demonstrated. Finally, it is important to make reference to the government calendar in the UK, regarding the new "Zero Carbon Emissions" program in new houses.

These studies demonstrated that a substantial amount of additional investments made in sustainable projects, are based on specific costs such as simulations, introduction of new technologies and integration of sustainable practices into the project. The studies also evidenced that it is always important to introduce these measures as soon as possible, mainly in the design phase.

3. Economic feasibility adapted to Portuguese reality

The above mentioned studies were carried out according to their national contexts. Thus, this paper intends to show a methodology that is being developed to assess the cost-effectiveness of some sustainable measures to be applied to commercial buildings, adapted to the Portuguese reality. The study will be carried out according to sustainability criteria based on two assessment tools:

- BREEAM (Building Research Establishment Environmental Assessment Method) (UK) – the first environmental assessment tool that was developed in the world;
- SBTool (Sustainable Building Tool) (Can) a tool which clearly identifies sustainable criteria (establishing environmental, social and economical criteria), and has been disseminated in several countries around the world (the Portuguese adaptation of the SBTool is in a pilot phase).

The various stages of this methodology are outlined in figure 2 and described below.

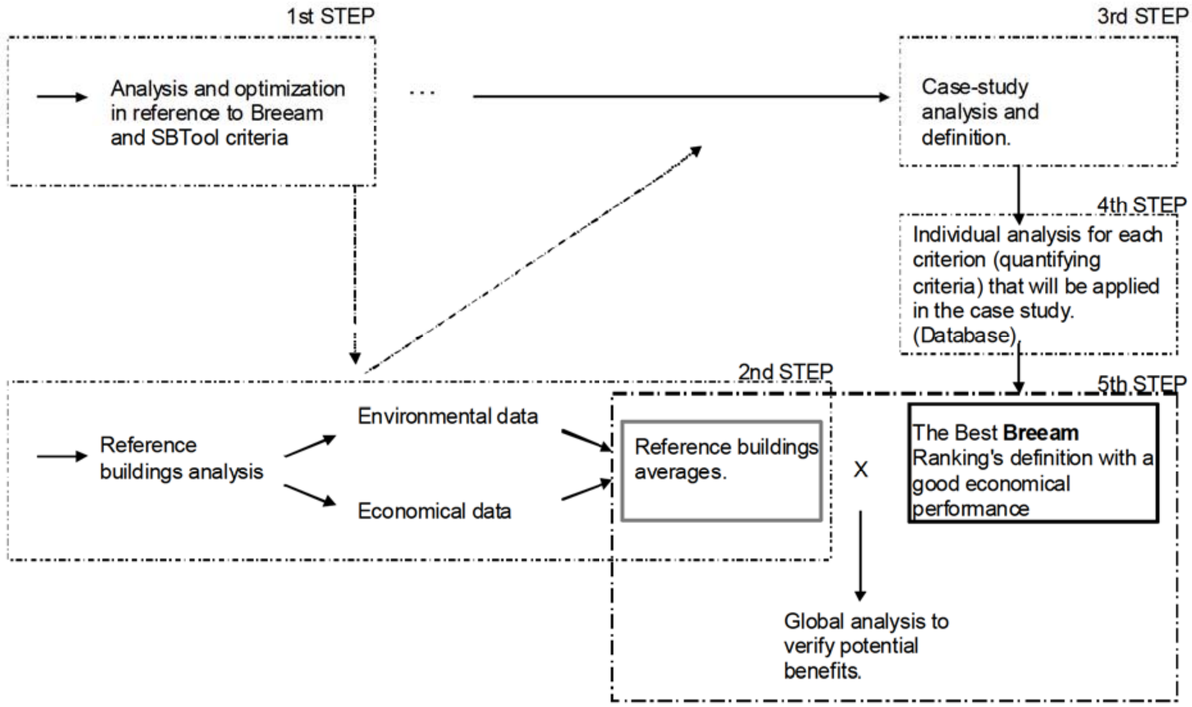

Figure 2 Structure of the proposed methodology

3.1 Guideline for sustainable construction and action analysis (1st step)

The first step of the proposed methodology is based on the criteria of analysis of a case study based on the previously mentioned tools (Breeam and SBTool), in which the criteria were identified and separated into different groups:

i) “Criteria of complex quantification”, which produce indirect benefits, and are related to:

- Biodiversity;
- Measures with ethical values;
- Certain IEQ criteria (Indoor Environmental Quality);

ii) Sustainable criteria already covered by the Portuguese legislation. These are not considered in this research as they do not introduce any added value or differentiation for new challenges on Sustainable Buildings, as they are presently compulsory and related with:

- IEQ (Indoor Environmental Quality) covered by current legislation;
- Other criteria covered by current legislation.

iii) Quantified criteria through cost benefit analysis related to:

- Materials,
- Water management;
- Energy management.

These quantified criteria will be the main focus of this research. They may not be considered key elements but they can be directly quantified by cost benefit analysis, which allows for a binomial effect:

- Obtaining measurable results (direct benefits) for stakeholders - one of the main aspects for the decision-making of the project promoters and also the major contribution to the sustainable property/business value;
- Meet critical sustainable criteria based on international tools. These criteria are considered crucial to perform the best ranking proposed by these tools (See Figure 3).

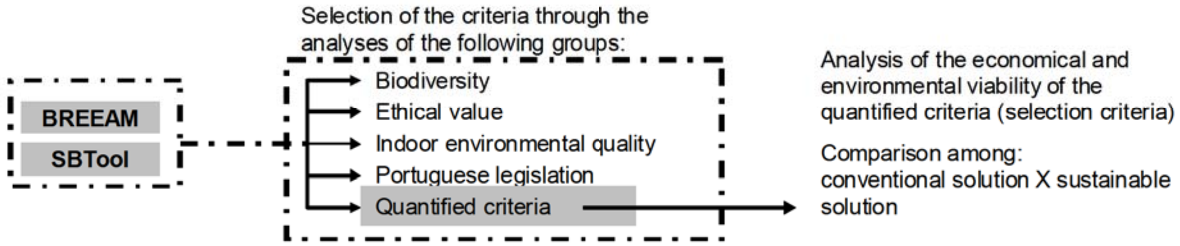

Figure 3 Selection procedures for the optimization of the criteria to be analyzed

Through this analysis it was possible to identify 116 SBTool criteria of which:

- 22% are already included in the Portuguese/ European legislation;
- 24% are related with quantified criteria.

and 72 existing criteria from the Breeam-Retail:

- 25% are already included in the Portuguese / European legislation (equivalent to the English legislation);
- 26% are quantified criteria (as above) of which a high incident is associated to profitability factors (of promoters or owners).

In spite of not being considered here, other indirect benefits may determine changes in the building performance related with economical results. An example is the IEQ (Indoor Environmental Quality) criteria which promotes excellent results in human and organizational productivity, when buildings are strongly related with services or commercial activities.

The profitability factor to owners and promoters must experience a cultural change in the interpretation of results to reflect a medium-long term perspective (positive balance between: Investment -first capital- cost, acceptable pay-back and higher cash flows during the lifecycle building or analysis period) as opposed to short term expectations (low investment cost -first capital- and comparable negative results during the building lifecycle).

The objective of this research is to recognize the evidence provided from the reduction of environmental impact when sustainable tools criteria are applied while at the same time demonstrate that these may lead to important economical advantages through direct benefits resulting from different actions on the reduction of consumption, conservation/maintenance effects and the added-value increase for Shopping Centers.

For an economical and environmental evaluation through this methodology, an individual application will be necessary. This will be demonstrated later in step 4.

3.2 Reference Building Definition (2nd step)

While actions were optimized through Breeam and SBTool criteria, environmental and economic data have been collected on three existing Shopping Centers in Portugal (which used equivalent construction methods) – Dolce Vita Porto (DVP), Dolce Vita Coimbra (DVC),Dolce Vita Douro (DVD). These commercial buildings belong to the Chamartín Real Estate Company.

Through the obtained data of those buildings, which will be referred to as “reference buildings”, it has been possible to establish efficiency indexes (consumption/m2/year and consumption /1000visitors/year) as can be seen in tables 1 and 2. In addition to these indexes (energy, water, CO2 emissions, recycled and non-recycled waste), global values will be compared with national and international "benchmarks" (see table 3). Nonetheless these can be analyzed according to the IEE (index of energy efficiency), specified for shopping centers, which is comprised by the law 79/2006 (that emerged from the transposition of the EPBD - Energy Performance Building Directive into the Portuguese law) which can be visualized in table 4.

It is important to point out that the values for the Portuguese reference building in table 3 are not directly comparable with the IEE values in table 4. To establish this comparison it would be necessary to separate the different types of consumption (heating, air conditioning and lighting) and to be identified along with the appropriate correction factors set out in the law 79/2006. The values listed in the previous tables (1, 2 and 3) represent actual and overall consumption from the different shopping centers.

Table 1 The efficiency index of the total demand (resources) and Chamartín's average per sqm (without climate correction).

DVS demand /sqm (construction area -GLA -Parking)							2006
Shopping Center	*Economical data*	*Environmental data*					
	Euros	Energy		Waste		CO_2emissions	Water
	Euros/m^2	kWh/m^2	Tep/1000m^2	Recycled /m^2	Non recycled / m^2	$KgCO_2$/ m^2	m^3/m^2
DVP	32.96	474.86	137.71	6.91	20.87	196.59	0.83
DVD	22.12	283.50	85.07	6.24	11.08	117.37	0.50
DVC	29.43	370.69	107.50	6.79	21.45	153.46	0.79
Average	28.17	376.35	110.09	6.65	17.80	155.81	0.71

Table 2 The efficiency index of the total demand (resources) and Chamartín's average per 1000 visitors.

DVS demand /1000visitors			2006
Shopping Center	*Environmental data*		
	Energy	CO_2emissions	Water
	KWh/1000visitors	$KgCO_2$/1000visitors	m^3/1000 visitors
DVP	1458.80	603.94	2.56
DVD	1265.24	523.81	2.24
DVC	1105.02	457.48	2.39
Average	1276.35	528.41	2.40

Table 3 The average efficiency index of Shopping Centers - International benchmarks. (Source: CIBEUS and other researches).

Annual Average energy Intensity (existent Shopping Centers)			
	GJ / sqm	KWh / sqm	Kgep / sqm or Tep / 1000sqm
Canadian Shopping Center average	1.30	361.40	**105**
UK Shopping Center average	1.04	290.00	**84**
Portuguese reference building	1.35	376.35	**110**

Table 4 The efficiency index, specified for the Shopping Centre in agreement with the decree-law 79/2006 (RSECE, 2006)

Existent buildings		
Activity types	Building typology	IEE (Kgep/ sqm.year)or (Tep/1000sqm.year)
Commercial	Commercial center	**190**
New buildings		
Activity types	Building typology	IEE (Kgep/ sqm.year) or (Tep/1000sqm.year)
Commercial	Commercial center	**95**

It is important to point out that the shopping centers are situated in different locations, thus different climatic factors were obtained for the "reference buildings". A basic comparison of the average values showed by the three buildings would be incoherent, as they would reflect the different climate features of the buildings performance.

With this in mind and influenced by the methodology used in the Decree-Law 79/2006 to define the IEE index (Energy Efficiency Index) for different building typologies, as referred above, climatic correction factors were applied to these shopping centers located in Coimbra (DVC), Porto (DVP) and Vila Real (DVD), when necessary.

Through these results, it will be possible to establish a comparison, on an economical and environmental level, between the “reference buildings” and a “case study”.

3.3 Case study definition (3rd step)

Following the analysis of the reference building and the verification of the selected criteria (from the sustainable tools), this methodology will be applied to a case study, the largest Iberian Shopping Center, which also belongs to “Chamartín Real Estate S.G.P.S., S.A”. The building is being constructed in Amadora, near Lisbon with a total construction area of 423.000 m2, including parking and 122.000 m2 of GLA (Gross Leasable Area). This project was designed with a new concept brand for Shopping Centers, named “Dolce Vita”, a world market reference. It will include wide reading spaces, stores, a food court, recreation areas and supermarkets.

The chosen typology is quite relevant (in relation to its dimension) since a commercial building of this size will have high environmental, social and economical impacts (Environmental impact, resulting from its construction and management, social and economical impacts, resulting from future changes in local reality, employment and road flow increases).

An evaluation of the shopping center, which is presently in the construction phase, has been carried out in order to verify if any sustainable criteria have already been applied. The measures which have already been applied will be compared (economic and environmental factors) with the reference building options, while the criteria which has not been applied will be compared with the present project options (considered less sustainable measures) of the case study.

The objective at this phase is to validate the selected criteria with an economical and environmental feasibility analysis.

3.4 Cost- effectiveness of sustainable construction indicators and database creation (4th step)

Only the Breeam tool will be used for evaluation during this stage. The final objective will be not only the analysis of the selected criteria but also to assess in which place of the ranking established by Breeam the case study results will be put on.

At this stage, the cost-benefit analysis of each sustainable measure (applied individually) will be analyzed through a simulation carried out in the selected commercial building previously mentioned.

First of all the information will be organized by categories that can be quantified (energy, water and material). This information will then be structured according to the organization schemes used in several sustainable tools.

The expected results are identified by environmental (CO2 emissions, consumption reductions and other important ecopoints) economical (investment cost, generated NPV (Net Present Value)) and payback period data. The database will be completed in the following steps:

1. Identification of BREEAM criteria that correspond to the project phase and that will be analyzed in the database. For each indicator, there are actions to reach objectives.

2. Identification of actions, which were already identified in the studied building, and which consider the Breeam criteria in the database. Analysis of actions should be accomplished through the comparison with conventional actions used in the reference buildings.

3. Identification of actions that were not found in the studied building and that should be filled out in the database. Analysis of these actions should be accomplished through the comparison with present existing measures in the studied building, regarding potential changes.

The final information will be organized in a database similar to the example shown in Table 5. Regarding outcomes from the implementation of 3 sustainable measures on the referred table, it can be demonstrated the following information.

- Energy example – Comparison between Installation of energy-efficient lifts with Regenerative system (SI –Sustainable Investment) and conventional lifts (CI - Conventional investment) – modification just applied in 30% of the lifts;
- Water example - Comparison between installation of dual flush WCs - 4,5 litres (SI- Sustainable Investment) and simple flush WCs (6 litres) (CI - Conventional investment);
- Materials example – Comparison between thermal insulation with low embodied impact (corkboard) (SI – Sustainable Investment) and thermal insulation with high embodied impact (extruded polystyrene - XPS) (CI – Conventional investment).

Presupposes considered: Inflation rate (year average) - 2, 5% Economic Cycle Analysis -20 years; Electricity price increases – Growth rate (year average) - 3%; Water price increases – Growth rate (year average) - 1%; Discount Rate for NPV (Net Present Value) – 6% (NPV - The present value of an investment's future net cash flows minus the initial investment).

For an additional Investment cost of € 72 198, 41 (SI- Sustainable Investment for the referred 3 examples), equivalent to 9,8% more than CI (Conventional Investment), It results on a total NPV of € 159 226,83 (equivalent to € 1, 31/sqm). The simple pay-back for the total investment is reached in 5 years.

Table 5 Database structure

Application example - Comparison result (conventional versus sustainable criteria)									
Case-study: DVT Shopping Center (Lisbon) Type occupancy: RETAIL Phase: Design Phase									
Breeam-Retail			Economical data			Environmental data			
Related category	Ref.	Criteria	Investment cost (€) and (%)	simple payback (years)	NPV (20yrs) (€)	KgCO2 reduction (per year)	Reduction consumption (%)(un/year)	embodied energy reduction	Breeam ranking
Energy	Ene8	Up to two credits are available where evidence provided demonstrates the installation of energy-efficient lift(s).	**29 799,00 (>14%)**	8	27407.60 (0.22€/sqm)	**< 12 709 (79.5%)**	**< 79.5%** (KWh)		2
Water	Wat1	1. All WCs have an effective flush volume of 4.5 litres or less. 2. Where dual flush toilets are specified they have guidance or symbols instructing the user on the appropriate operation of the flushing device.	**5 400,00** (13.4%)	1	168 818.64 (1.38€/sqm)		**<4 727 (m3) (<25 %)**		1
Materials	Mat6	1- Where evidence provided demonstrates that thermal insulation products used in the building have a low embodied impact relative to their thermal properties, determined by the Green Guide to Specification ratings.	**36 999,41 (>8 %)**	no payback	- 36 999,41 (-0.30€/sqm)			<7621 MWh (85%)	1
		total Investment (3 examples)	72 198,41 (0.59€/sqm)	5	159 226,83 (1.31€/sqm)				4

3.5 Defining the best Breeam ranking with a good economical performance

Following the analysis and the completion of the database with quantified criteria, the pre-assessment estimator (from the Breeam-retail) will permit the verification of rankings achieved in the case study. One of the aims of this work will be to compare and analyze the economical and environmental behaviour of three different scenarios (with different Breeam ranking) (See Figure 4). These are:

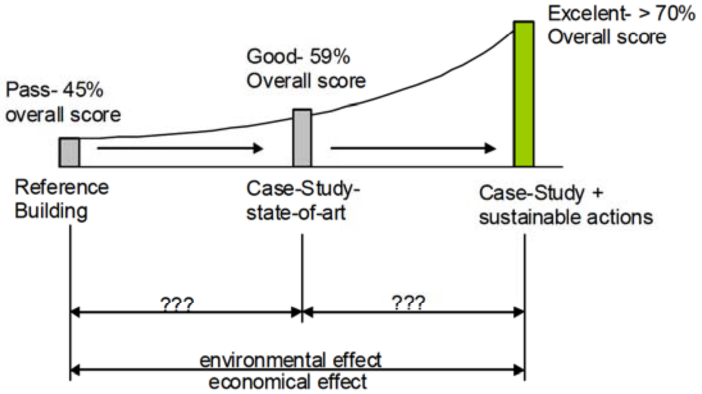

Figure 4 The comparison and analysis between different scenarios.

Scenario 1: The case study with approximately 45% overall score. (The same as Reference building)

Scenario 2: The case study with approximately 59% overall score (Actual situation of the case study with criteria already applied on the case study)

Scenario 3: The case study with >70% overall score (Breeam excellent ranking) (Case-study + criteria that were not considered in the case study at the time).

This process will be achieved by adding other Breeam criteria (referred above as "criteria of complex quantification"), which have solutions with low first capital impact.

The referred capital costs along with the new criteria will be considered as investment costs in both cases when totalizing the complete NPV and Payback effects on a global basis for the case study. Nonetheless the potential benefits of these criteria will not be considered as they provide "indirect benefits" and are difficult to quantify. This is the reason why the analysis ("Criteria of complex quantification") will focus on solutions with a low investment cost impact. When this is not possible other solutions with a more economical impact will be used with the assurance that the expected NPV and payback results will not be negatively affected on a global basis, and at the same time capable of reaching the desirable overall ranking.

The explicitness and transparency that demonstrates efficiency benefits, and the way how to reach economic value in sustainable buildings, are a decisive incentive for stakeholders and for real estate market in general.

However, it is important to remember that this study will be defined for a specific typology in a certain area. Therefore the result will be conditional and will not allow a direct and immediate application of the best scenario methodology into other projects.

Nonetheless, through its main output information (costs definition, database output and new methodology), this study can serve as an important guideline to help different stakeholders involved in new sustainable building projects focused on economical benefits.

4. Conclusion

This paper seeks to define methodologies and objective contents to achieve newer and larger real estate projects (services /commercial), supported by sustainability concepts.

This study used the "Breeam and SBTool" tools as they are considered rigorous and are recognized among universities and academic environments and are essential resources for the study and development of Sustainable Building Evaluation.

Finally, this study seeks to define new methodologies and analysis aiming to integrate different action fields such as sustainability, functionality and economic feasibility (cost effectiveness) which more than often are used separately.

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