Increasing the value of buildings through environmental design

The environmental design of the built environment can be defined as a design strategy focused on reducing the depletion of resources such as energy, water, and raw materials. Sustainability in new constructions and refurbishment has achieved paramount importance in the last decades for all the agents involved in building management such as urban planners, policymakers, developers and designers as well as citizens, due to social, economic and environmental implications.

The application of environmental design to new and existing buildings becomes a tool to increase the value in two ways: on one hand, the use of materials and techniques with smaller environmental impact can make the building more attractive for particularly conscious consumers. On the other hand, the use of adequate strategies for heating, cooling and ventilation can make the building less energy consuming. The purpose of this paper is to analyse how environmental design can positively affect the cost and final value of a building.

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Introduction

Comfort achievement in building is the final objective for many designers. Maintaining comfort conditions uses resources and energy, thus efforts must be done during the design phase to decrease the operational costs for maintaining the performance of the building. Environmental design is focused on reducing the use of resources while providing final products of high quality. This is achieved by optimising the potential for 'passive' strategies which make use of the environmental conditions (Desideri et al. 2010).

The environmental conditions in which human beings are in a state of comfort are limited within a small range of temperature, humidity and air speed. These conditions are mostly imposed by our physical constitution, but are also affected by cultural standards.
As comfort conditions do not always exist in nature, men have developed clever strategies to generate barriers that protect them from adverse weather and make them feel comfortable. These strategies include the development of buildings appropriate for the local climatic conditions (Ralegaonkar and Gupta 2010). Some years ago in the work of Garg (1991) it was concluded that two thirds of the cases of discomfort could be solved by using simple passive techniques based on thermo-physical and geometric properties of buildings.

Responding to local climatic conditions, environmental designers will try to achieve indoor comfort conditions with the least possible expenditure of energy (Aksoy and Inalli 2006). These principles have guided the design of traditional buildings, which take advantage of local conditions through the layout and shape of the building, and in recent times have inspired the concept of 'passive' architecture (Parasonis et al. 2012).

Nowadays, comfort conditions in buildings are generally achieved with large amounts of energy, as little attention is paid to the resources needed. As buildings are responsible for 33 % of the total energy consumption in the world (Urge-Vorsatz et al. 2013), buildings are major contributors to problem of climate change and, more generally, environmental pollution. This situation clearly needs to change.

As indicated by Alaa El Dean El-Alfy (2010), sustainable development meets the needs of the present generation without compromising the ability of future generations meet their own. 'Green' buildings refers to buildings which are environmentally responsible and resource-efficient throughout their life-cycle, from siting to design, construction, operation, maintenance, renovation, and demolition (Ji and Plainiotis, 2006). Thus these buildings attempt to meet the needs of society whilst reducing their impact in social, economical and environmental terms.

From an economical perspective, there are benefits in the improvement of energy efficiency buildings and resource use in buildings.
The implementation of sustainability can be a powerful tool to save on energy bills, to reduce energy dependence and to increase competitiveness.

Environmental design has many benefits; among others, it can reduce annual utility expenses and maintenance costs (Zhou et al. 2003). In order for this design approach to be effective, significant decisions regarding technology are taken during the design phase and have an effect on the final performance of the building.
Nowadays, several assessment methodologies exist to evaluate the sustainability of buildings. These can be categorised into three groups (Macías and García 2010):

- those based on the evaluation of actions and associated impacts, such as LEED V3 (USGBC, 2014) and BREEAM (BREEAM, 2014);
- those based on the concept of efficiency such as the Japanese CASBEE (CASBEE, 2014).
- those based on a tree structure with different categories and criteria, in order to be adapted to each country particularities. In this case we can find the SB tool (IISEB, 2015).

Increasing building value through environmental design

'Value engineering' should be considered as a philosophy to optimise the value of an item fulfilling the objectives of its purpose. In our case, this involves many aspects of the design of buildings without compromising their final quality. During the design phase, engineers and architects must select and finalise materials, and components of the building. Environmental design includes the sustainability assessment of construction products, which is becoming easier to conduct through Environmental Product Declarations (EPD).

When considering the sustainability of the built environment, the focus quickly moves to energy retrofit projects, since existing buildings have high environmental impact. Economical considerations are also involved, as existing buildings often present high operational energy costs as well as a large potential for energy savings.

Economic benefits of environmental design

The economic benefits of environmental design include lower energy and water consumption, smaller construction waste, lower operations and maintenance costs, lower environmental impact, and increased comfort, health and productivity. Unfortunately environmental design can require higher investments during design and construction phases. However, this situation is changing, and operational savings do not have to come at the expense of higher initial costs.

Some environmental design features have higher initial costs, but payback periods are often short and the life-cycle cost typically lower than the cost of conventional buildings. Apart from those direct savings related to energy consumption, there are other potential economic benefits that can increase in the value of the building if the correct indicators are shown:

- increase in health and comfort of the building occupants. This can reduce levels of absenteeism and increase the productivity of workers. For instance, it has been estimated

that improving occupants' productivity in commercial buildings, considering Indoor Environmental Quality (IEQ) aspects, in the US could bring economic gains between $20 – $160 billion in 1996 (Jin et al. 2012);
- longer building lifetime and less investment in retrofitting and maintenance;
- higher community acceptance and support;
- reduced costs from air pollution at the regional scale.

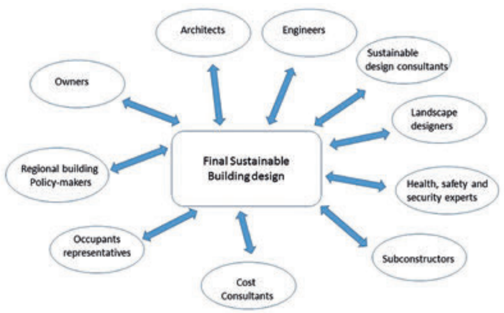

Figure 1 - Agents involved in sustainable design

Initial cost of environmental design

A project should include environmental design in its conceptual phase in order to realise the full benefits. The design team should be composed by all the agents involved in the final product, in order to increase the synergy of the solution. Environmental design requires close cooperation of all these agents (Figure 1) who form an integrated design group. The team should assess the sustainability of products and components used in the building in order to meet the specific sustainable requirements of the project.

Furthermore, the goal of the design team is to develop innovative solutions without increasing the budget of the building. Most of the times, environment-friendly products are more expensive than conventional ones. Nevertheless these additional costs imply higher energy savings during the life of the building, and therefore if the economical savings overtake the initial expenses, the investment is profitable.
Significant decisions must be taken in order of not to increase the initial and final cost of the building:

- eliminate unnecessary elements in the building. Designers have to consider whether some elements can be avoided, like internal doors, ornamental features, etc. This will decrease the use of materials, make the building lighter and decrease the initial cost;
- use recycled materials and modular solutions;
- choose a correct location for the building in order to decrease the initial need for site infrastructure. Some particular locations increase very much the initial cost because the waste disposal or de conditioning of the site costs are very high. This must be avoided by choosing a better location;
- have a bioclimatic approach to study how to achieve high comfort levels for the occupants, adaptating geometry, orientation and construction techniques to the climate of the site (Barajas et al., 2015).

Environmental design aims to create buildings which are more comfortable and healthier than conventional buildings without implying an increase in costs by supporting comfort conditions with minimum energy demand.

Cost savings across the life of green buildings

The benefits of green buildings should be considered throughout their life-cycle and not just in comparison to the upfront costs, because savings resulting from investment in environmental design usually exceed the additional upfront costs.

As well as there are design decisions that can reduce the initial cost of a building, there are design solutions that can reduce the operational cost of a building. The aim of these efforts is to decrease the energy cost across all the life-cycle of the building. For example:
- optimise site and orientation. An appropriate choice of site will decrease the energy cost across the life-cycle. Solar radiation, natural ventilation and shading can decrease the use of energy used to achieve the comfort of the occupants;
- choose the best room distribution considering the future use the building;
- install adequate thermal insulation. A well-insulated envelope limits heat losses and therefore less energy will be needed to reach the thermal comfort conditions.

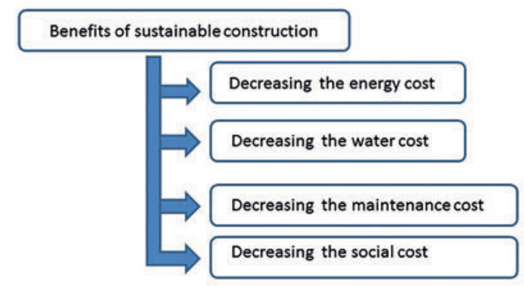

Figure 2 - Benefits associated with environmental design

The benefits of environmental design include some elements that are relatively easy to quantify (Figure 2), such as energy and water savings, as well as those that are less easily quantified, such as the decreases in maintenance and material costs, as well as other indirect social and environmental benefits.

Mid-term energy savings: decreasing the energy cost

Nowadays, many commercially available technologies can help designers to effectively minimise a building's energy costs. However, these technologies should be integrated in the first stages of the design process.

A complete strategy should be adopted in order to decrease the medium term energy costs. The aspects to be considered are referred in Table 1. First, a high percentage of the total building energy demand is due to heat losses through the building envelope. Appropriate envelope insulation will limit heat losses. Nowadays many different materials are being developed to meet the need for energy efficiency, environmental design and cheaper costs. Additionally, adequate envelope design can maximise the use of natural ventilation techniques which help reducing the heat gains,

Table 1 - Energy implications of sustainable building in the mid-term perspective

Item	Measure	Action
Building envelope	Window distribution	Optimise solar radiation and natural ventilation
	Wall insulation	Sustainable materials. Ventilated façades
	Efficient windows	Automatic performance avoiding thermal bridges
	Thermal bridge	Improve continuity between insulation layers to avoid heat losses
Mechanical Systems	Main system controller	Energy management. Choose the best way to produce/consume energy. Smart-consume or energy-saving
	Heating, Ventilation and Air Condition systems (HVAC)	High efficient systems: forced ventilation, underfloor heating, heat pumps, etc.
	Domestic Hot Water	Produce it through renewable energies such solar thermal collectors and heat pumps. Recapture energy from waste hot water.
	Low pressure ducts	Enlarging the duct sizes for saving energy
Lighting	Increase day lighting.	Add skylights
	Reduce lighting intensity	Appropriate lighting power
	Perimeter automatic daylighting controls	Daylight sensors

such as ventilated façades, atria and effective distribution of windows.

A ventilated façade generally consists in a continuous layer placed over the building wall leaving a naturally ventilated cavity. Depending on outdoor conditions, a cooling effect can be produced by the ascending flow of air, which is induced by the chimney effect, reducing the heat gains (Giancola et al. 2012).

An atrium is a building central space mainly designed to expose indoor spaces to daylight and to maximise direct solar gains. An appropriate atrium design can also help reducing the heat gains of by increasing the natural ventilation (Moosavi et al. 2014).

HVAC systems are used to create comfortable indoor conditions in buildings. An efficient HVAC system can also reduce the amount of energy needed to meet the demand for heating and cooling the building.

Currently, air- and ground-source heat pumps are one of the most advanced technologies available for heating/cooling and domestic hot water (DHW). Ground-source heat pumps collect energy stored in the earth and use it to heat water. The energy stored in the ground is an extremely reliable and constant energy source. The heat pump uses some amount of electrical energy to accomplish the work of transferring heat from the original source to a medium (usually water) with very high efficiency, as for each kW of electric energy used by the system, a higher quantity of heat is extracted form the source. Heat pumps emit no harmful substances and use very small amount of electricity. This technology can be used in combination with solar thermal heating and condensing gas boilers, though it needs to be managed by an intelligent control to guarantee the lowest use of energy and the highest level of comfort. The system must be able to choose the best energy source to decrease the operational cost in each moment: smart energy supply.

Regarding lighting, building openings can be designed to increase the penetration of natural light and therefore reduce the artificial lighting demand where possible. Energy-saving light bulbs can be installed and steps have to be taken to ensure that lights are turned off in unused areas.
To provide a general quantification of energy costs is difficult, but literature indicates than energy saving induced from eco-feedback system can range from 5 % to 55 %, (Pisello and Asdrubali 2014; Azar and Menassa 2012; Fabi et al. 2013; Chen et al. 2013; Selig-man et al. 1978; Yang et al, 2014).

Water heating represents also an important amount of the energy demand across the building life-cycle. The use of roof condensers and a rational layout of the hot water distribution system (minimising the distance between heater and consumption points) can decrease significantly the energy lost in the system.

Mid-term water savings: decreasing the water cost

Nowadays, several techniques can be used to reduce the water consumed in buildings. These technical devices decrease the midterm use of fresh water and not necessary increase the cost of the design project: ultra low-flow showerheads, faucet aerators, or dual-flush toilets. In certain application, the re-use of non potable or regenerated water can be proposed. Environmental design will also be focused on the necessity to improve the efficiency of water uses. This can be done implementing new water reuse systems and better controls on water losses (Matos et al. 2013). Green building water conservation strategies can be considered into four categories (Kats et al. 2003):

- efficiency of potable water use through better design/technology;
- capture of grey water – non-faecal waste water from bathroom sinks, bathtubs, showers, washing machines, etc. – and use for irrigation;
- on-site storm water capture for use or groundwater recharge;
- recycled/reclaimed water use.

Facilities repair: decreasing the maintenance costs

Environmental design is intended to increase durability and easier maintenance. The accessibility to services areas or the use of durable materials will decrease maintenance and repair costs. Seasonal maintenance strategies will promote proper use of facilities getting an efficient use of resources.

Furthermore, environmental design potentially improves efficiency and convenient collection of recyclable materials, such as glass, paper, plastic or others. This affects the environmental value of the building by reducing annual disposal costs for the occupants.

Indirect benefits of environmental design: social cost savings

Environmental design has additional benefits related to social and life quality aspects. It is difficult to quantify their economical effects in a single indicator, but there is no doubt that these aspects increase the value of the final building (Frontczak, et al. 2012). For instance, a lower absenteeism and improved productivity is related to these types of buildings.

The social response to some of the features of green buildings can be an increase in people's satisfaction, reduction in mistakes, reduced absenteeism and increased productivity, thus reducing labour costs (Haynes 2008).

However, economical benefits are not the main motivating factor everyone. The cost-effectiveness of green buildings makes environmental design a pragmatic way to ensure the protection of the planet's resources. Furthermore, buildings that are constructed or retrofitted according to environmental design usually provide high-quality indoor environment, thereby decreasing the risk of illnesses in the occupants due to indoor pollution.

The retrofit of buildings occupied by households in conditions of fuel poverty can result in substantial energy savings. A retrofit based on environmental design can tackle fuel poverty problem with high cost-effectiveness and generate additional benefits (Urge and Tirado 2012). For example in Spain domestic building retrofits generate near 17 full-time workplaces per million Euro invested, or 47 full-time workplaces per 1,000 square meters retrofitted domestic area (Tirado et al. 2012). Other social, economical and environmental benefits are linked with the refurbishments of existing buildings, such as the reuse of materials (decreasing the overall environmental impact), possible reductions in transport costs, reduced landfill disposal, local economic development, retention of community infrastructure and neighbourhood renewal and management (Power, 2008).

There are several certification programmes such as Green Globes and the U.S. Green Building Council's LEED: Leadership in Energy and Environmental Design Green Building Rating System. These certifications aim to certify the 'performance' of green buildings, or how much 'sustainably designed' is the building, in order for society to take it into account.

Conclusions

This paper provided an overview of the value added to green buildings through environmental design. The main points arising from this reflection can be summarised as follows:

- There is a common perception that green buildings are more expensive than conventional buildings. This might have been the case in the past but the present situation is much more favourable;
- Green buildings increase the energy savings across their life-cycle. The over investment due to environmental design, if quickly recovered, can generate earnings;
- Environmental design encourage scientist to investigate and create new materials, building solutions and HVAC systems more environment-friendly;
- There are several social benefits associated with improved health and enhanced building occupants performance.

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