BUILDINGS THAT ARE SUSTAINABLE

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Abstract

Often the word “sustainability” is understand as “reduction of the energy consumption” of buildings; indeed, the energy consumption is a matter of sustainability, but that word has broader a more complex implications. In fact, the sustainability of a building concerns also its embodied energy, the consumption of natural resources, the use of land and so on, with issues that cover its entire life cycle.

On the other hand, it’s easier to calculate the energy consumption than the other parameters of the building sustainability, and assessment methods (Leed, Spear etc.) are often considered too laborious to be adopted by small developers. Additionally it is possible to recognize some lacks in every rating system if they are compared with the most common definition of sustainability.

The paper shows the intermediate step of a Research that aims to produce guideline for the building activity in the Rovigo area in Italy. The authors are working, together with the Rovigo public administration, to produce a “sustainable building code”, based on a review and a fill in the assessment methods adopted by other European Countries. On the basis of this, the paper evaluates the relevance and the effectiveness of the proposed actions to be taken by developers, architects and builders.

The distinctive point of this work is the improvement of the voluntary adoptions of such actions, which differ from the compulsoriness of imposed regulations.

1. Energy efficiency and architecture: Europe - Italy

As a consequence of the 1973 War of Kippur, the Western Countries understood for the first time their state of energy dependence from oil, and from the Countries that supplied it to their economies. During the 18 days long war, where Syria and Egypt fought against Israel to conquer back some territories lost a few year before, the price of oil doubled. In the next months, OPEC decided to support the costs of war paid by the Arabic Countries by rising further the price of oil. This had serious consequences on the Western Countries, which supported the government of Israel.

Europeans where particularly affected by this, and the subsequent 1974 energy crisis taught them that oil, its derivates, and energy are not endless resources. The crisis awoke the European Governments for the fear of a future potential lack of energy resources and guided the approval of several energy regulations meant to lower their dependence from foreign resources and policies, especially from oil derivates. A diversification process of the energy resources was promoted in many strategic fields of industry, thus increasing the share of gas, coal and hydroelectric generation, especially on highly energy reliant industries and power plants. Private transportation and domestic activities were severely struck by the energy crisis too (Manfron, 2007).

The built environment is acknowledged to be responsible for over one third of the energy consumption of many Developed Countries. However, this share is likely to be higher if one considers the energy consumption of building-related activities too (production of build materials, their transportation, etc.) In Italy,

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the built environment consumed 43m TOE[6] in 2004. The national building stock features more than 25m dwellings in almost 12m buildings, ⅔ of which are buildings built before 1974, thus before the adoption of any energy regulation. For this reason remarkable goals of energy efficiency are far to be reached, event thought the industry is now keen on the construction of "sustainable" or "green" buildings. In fact, other factors have to be considered when assessing this topic. For instance, the increased welfare of the European population and the higher levels of comfort required are factors that cause a constant growth of the energy consumption. Larger buildings, warmer internal winter temperatures and the widespread diffusion of large electrical appliances, offset the benefits of more efficient buildings and "class A" electric machines. The consequence of this is a constant growth of the energy consumption in many European Countries. This affects the electric requirement of private dwellings, but concerns the overall consumption of the building too.

The Italian legislation defines as "historic" a vast number of buildings, even though all of they don't have relevant appearance of a specific social value; by the way, such buildings are protected against demolition or major changes. On the other hand, this may not be the real problem even if there it was convenient and adequate politics and incentive at the aim to renovate the building stock. For these reason the renovation of the building stock is pretty slow, and despite the increased number of new buildings that comply with energy stringent goals, the old building consistently affect the final result.

While regulations adopted in the 70s where specifically meant for new buildings, Italy marked a milestone in 1991 when Law n° 10/91 and the subsequent updates and guidelines extended principles of energy efficiency to old buildings. According with this regulation the general targets of efficiency are extended to old buildings whenever major restorations works occur.

Instead actually, as in the nearly totality of the European Countries, in Italy who wont to act a re-qualification of an old building may take advantages from some incentive-pay that encourage adopting small and medium system for the production of renewable energy or adopting other strategies to reduce energy consumes. It is influencing positively the building activity related to the renovation of the unsustainable building stock. But this phenomenon invests only the minority of the building stock: the vast majority of the residential buildings in fact are inadequate to the current standards of quality and they are own by the State, which still deficits a good and active strategy about this matter.

2. Sustainability and assessment methods

Indeed, the word "sustainability" implies broader aspects, of which "energy consumption" is just part of the general definition and it can be applied only for a limited part of the life cycle of a building: the time of use. Additionally, along such period of time the effects of the building on the environment are not limited to this: water consumption, pollutants released by building materials, and so on are additional elements of its impact. However, the energy consumption can be considered the most relevant aspect of it, and the longer the life of the building, the more this issue must be addressed.

Therefore, the life cycle of a building starts from its concept level, and it should be acknowledged that the design process has a major influence on its overall sustainability, since the decision-making process occurs during this phase. After the building is completed, it can face some updates, restorations and extensions aimed at extend its life cycle, when it is finally dismantled, and its components dismissed, recycled or reused. For instance, according to the building technology more utilized in Europe, it can be assumed that 100 tons of materials are needed to build a medium sized dwelling (about 1100 sf of floor). Such materials are generally obtained through energy intensive processes (chemical, metallurgic or baking processes). The total energy required to build a medium sized dwelling is therefore around 6 or 7 TOE.

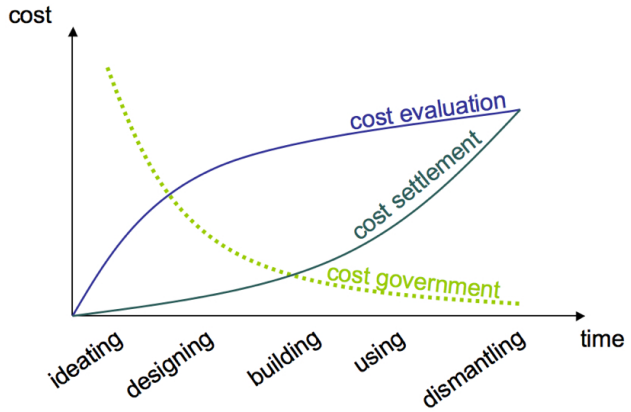

Figure 1 the graph explain how the analysis of the building costs is modified passing the time. In the "ideating" phase it is simpler to govern the building cost than in the other phases of the life cycle of a building; proportionally with the passing of time the cost evaluation and the cost settlement become more defined. The graph may represent not only the economic cost, but also the social and environmental cost of a building.

[6] The tonne of oil equivalent (TOE) is a unit of energy: the amount of energy released by burning one tonne of crude oil, approximately 42 GJ.

A sustainable building can be identified according to definition given in 1994 the first CIB International Conference on Sustainable Construction: it was defined as "*the creation and responsible management maintenance of healthy built environment based on resource efficient and ecological principles*" (C. Kilbert, 1997). Additionally in conclusion of one of the main chapters of the Sustainable Building Conference, held in Maastricht in 2000 are listed a series of characteristics that describe a sustainable building as follow: "

- *Consumes a minimum amount of energy/water over its life span;*
- *Makes efficient use of environmental-friendly, renewable or low-embodied energy materials;*
- *Generates a minimum amount of waste and pollution throughout its whole life span;*
- *Uses a minimum amount of land (whether brown or green field) and integrates well with the natural environment;*
- *Use local recyclable and reusable materials;*
- *Meets its users' needs now and in future*" (C. C. Gill, 2000)

The authors of these statements would like to stress the attention on the relevance of each phase of the building life, from the production and supply of the raw materials until the building demolition.

This school of thought creates several tools to asses the sustainability of buildings, they are meant to help the design team in the decision making program. Additionally they provide to the final user a series of useful information to understand the quality of the purchased building, its expected consumption of energy, and other parameters. The most effective information is based on a ranking system inspired by the equivalent certificates of efficiency released by large appliances suppliers to inform consumers on the power consumption of each machine.

Such tools have generally the form of checklists that guide the designer through the choices that will define the energy behavior of the building and of its surroundings. However, assessment methods are not mere checklists, but include guidelines and examples of best practices; additionally, they often inform on the relations each part of the building creates with the others.

Each assessment method has some original feature, and it is meant to assess a specific topic of interest. A survey on the most important ones shows the inhomogeneous relevance they pay to the main topics: each method assesses different topics or treats the similar ones differently.

Table 1 Building sustainability evaluation methods in comparison

Short name	**CASBEE**	**BREEAM**	**SBTool**	**LEED**
Extended name	Comprehensive Assessment System for Building Environmental Efficiency	Building Research Establishment Environmental Assessment Method	Sustainable Building Tool	Leadership in Energy and Environmental Design
Created by	Japan Sustainable Building Consortium	BRE Trust - UK Foundation for the Built Environment	International Initiative for a Sustainable Built Environment	US Green Building Council
Started in	2001	1990	1998	1994
Short description	Its main characteristic is the cyclic assessment of the building process, similar to a Life Cycle process. Costs are identified as environmental loads, while the benefits the building produces are given by the environmental and social qualities the it can provide to the city/are	It is the oldest assessment method and it is considered a reference even by later-developed methods. Its main feature is the relevance it pays to the economic of the building. If the same environmental goals are achieved the BREEAM grants an higher score to the less expansive one.	It is recognized to represent a second generation of assessment methods, as a consequence of its trans-national behavior. National councils tailored on each country's specificity can then adapt some international parameters.	It is a checklist where environmental features relevant for the architect's practice are assessed. Because of its simple approach it is often used as "ex ante" rather then an "ex post" tool, thus constituting a design tool.

Short name	**CASBEE**	**BREEAM**	**SBTool**	**LEED**
Main topics assessed	*Environmental Quality of the Building:* - Indoor Environment - Quality of Service - Outdoor environment on Site *Environmental Load of the Building:* - Energy - Resources & Materials - Off-site Environment	- Energy - Transport - Pollution - Materials - Water - Land Use and Ecology - Health and welfare - Management	- Site Selection, Project Planning and Development - Energy and Resource Consumption - Environmental Loadings - Indoor Environmental Quality - Service Quality - Social and Economic aspects - Cultural and Perceptual Aspects	- Sustainable Sites - Water Efficiency - Energy & Atmosphere - Materials & Resources - Indoor Environmental Quality - Innovation & Design Process

3. Building - City - Society. The extended relevance of assessment methods

The analysis of the main topics addressed can be considered a guideline not only for sustainable buildings, but for sustainable parts of cities too. In fact, each assessment method addresses three topics of the architect's profession: the building itself, its surroundings, and the value of the building in the city and the society.

The assessment methods work effectively in the design process of the building, since the achievement of a certain level of certification is generally meant as a design goal and is often part of the agreement program on the basis of which the architect is hired. Then, by controlling the architectural and technological aspects of the building and the easiness of its maintenance and operation, an assessment method actually overruns the targeted quality of the building alone. Additionally, all the assessment methods give ample instruction on water exploitation, energy conservation and use of raw and building materials.

The surroundings of the building are often addressed in terms of land use ratio and relative share of permeable and impermeable materials for landscaping and paving, thus and other devices at the aim to assess an enlarged "sustainable sphere of influence" of the building. Additionally, the links with public transportation are generally mentioned and promoted.

These scales of influence (building and surroundings) are related to the macro scale of the social, environmental and economic relevance, according the Triple Bottom Line (TBL) approach to the designing activity. Such approach derives from ISO indications as that "applying the concept of sustainability to specific buildings or other construction works includes an holistic approach, bringing together the global concerns and goals of sustainable development and the demands and requirements in terms of product functionality, efficiency and economy" (ISO 15392).

Indeed it is important to stress that the growing importance paid to sustainable buildings, is actively influencing the building market. In fact, since the sustainable discipline started a few years ago, new building products have been developing in substitution of older more pollutant ones, and the production of materials and components is still evolving to lower the energy consumption and the environmental impact of the building industry.

For this main reason, we can state that the rating systems for building sustainability have been able to provide a much larger push in the direction of sustainable cities.

Despite this analysis cannot be exhaustive even if it shows the relevance of the issue and the extension of the problems it should be dealt with. On the other hand, the set of assessment topics mentioned before, despite it is only a simplification, are probably complete enough to describe an object as complex as a building is. The discipline of sustainability is recent in the field of architecture, and the complexity of the building practices doesn't help for a quick and uniform diffusion of its principles. However, we argue that a positive and growing tendency has set, and it is necessary to increase and diffuse the know how of this discipline. By designing more sustainable building, we will achieve more comfortable, safe and conscious buildings that will lower both their the economic, social and environmental costs.

4. Effectivity of assessment methods

Despite the growing number of sustainable buildings granted of "green" certificates, it is quite difficult to evaluate the effective benefits achieved as a consequence of the variability of topics addressed and of the results provided. To cover this gap some international standards are being set by international normative consortium.

A large number of variables can affect the final result obtained by the appliance of a building rating system. Thanks to the vast literature it is more and more simple to valuate the quality (and so also the environmental performances) of an industrial activity or of all the other activities related to the production of goods that maintain fixed characteristics, performances, and format or composition. The building quality (and its environmental performances[7], too) is influenced from a series of actors that choose, design, calculate, evaluate, built, and check every single and inimitable part of the building in a context that is very different from building to building.

On the other hand a minimum level of building quality is set by regulations: indeed Municipalities, Provinces, Regions and Countries define the minimum level of building quality in a list of standards that have been always guaranteed and that are explained in Building Codes.

By now nearly all the environmental-friendly characteristics of a building depends from the adoption of more performing techniques and strategies that enhance the minimum standards. The adoption of such a series of best practices depends by the environmental behavior and the long view of the architect and the financier of the building.

Anyway, more and more urban areas are adopting (or still developing) a new generation of Building Codes based on instructions and examples inspired by the best practices that reduce the building loads on the environment: the majority of these suggestions and useful agreements derive by the sustainability evaluation methods listed before.

A rapid overview of the most recent development of legislation concerning the energy preservation in buildings, some important progresses could be identified. Probably, the most important step ahead in the European Countries is marked by the 2002/91 EC normative. This norm addresses all the sources of energy consumption in buildings, with a particular focus on heating, summer cooling, lighting and domestic hot water. The norm states that in several European Countries the topic of summer cooling should be addressed with a specific care, and means of natural ventilations should be adopted in such countries.

On the other hand, the analysis of the building sustainability is really different and also more difficult to evaluate than the energy efficiency. Having chosen methods for determining building sustainability there is always a great compliance from the options outlined from them.

To take a partial evaluation of the benefits embodied in politics for more sustainable building activity a comparison may be chosen between settings required in the performance levels listed in rating systems and the energetic save as a consequence of a new mandatory standard (R. Drogemuller, 1999). It may be useful to remember that building simulation and system performance methods, required different tools related to the different performance levels for each aspect, technology, and class of building, in each climate zone, social, environmental, and economic background. So it is clear that for an energetic evaluation it is necessary to govern a minor complexity than for the adoption of a holistic sustainable prescriptive approach, in which the decisions are more extensive, covering which elements are to be included.

By the way if a new mandatory standard about energy saving consent a strong reduction of the consumptions, it have to be considered that analogous politics have the potential to improve the quality standard of new buildings and of existing building stock, too.

Since from these considerations the present group of researchers of the IUAV University in Venice is now elaborating guidelines for new building codes according to the principles of sustainability.

In the literature there are no specific tools that consent the comparison between the various topic of sustainability and the various indicators of sustainability: only the Ecological Foot Print[8], Genuine Saving concept[9], and the evaluation of the embodied energy in buildings may be considered like a sort of “Esperanto language” between the designers and between the various rating systems. Unfortunately these methods are still inefficient and inadequate to the widespread query of clear, simple, and cheap information about the building quality and sustainability. Probably a further refinement will transform such methods in instruments that are adequate to the building decision making dynamics and the building cost managements.

Indeed, we can speculate that the guidelines included in the available assessment methods can guide through the design of more efficient, thus more sustainable buildings: this statement may be subscribed even if guidelines and assessment methods are well fitted in the context of adoption. This focus is more and more important in a Country like Italy, in which building technologies, typologies, characteristics and so on are really different between region and region (sometimes changing also in few square kilometers).

The analysis of guidelines and design directions carried out by the IUAV University of Venice will be used to create a new building code for the Rovigo County, in the North-East of Italy. The new guidelines will consent to set a series of building codes, one for each of the 50 Municipalities of the Province, fitting each other and also fitting the main international standards, indicators and suggestions about building sustainability. Inspired by sustainable principles, relies on a basic assumption: the more the code refers to common building practices of the region where it is meant to work, the higher the results that can be achieved. In fact, this will

[7] A “building performance” is the “ability of a building to fulfil required functions under intended use conditions or behaviour when in use” (ISO TS 21929-1). An “environmental performance” is the building “performance related to environmental impacts and environmental aspects” (ISO 15392).

[8] Is a smart definition to calculate statistically the surface of the Earth that a person or a country consumes

[9] The concept of genuine saving, the net saving rate in a national accounting framework encompassing resource depletion and environmental degradation, is extended to include technological change, human resources, exhaustible resource exports, resource discoveries and critical natural capital

create compulsory rules, inspired and adapted from assessment methods, which were previously adopted on a voluntary basis.

Probably the most suitable solution to promote sustainable building principles on a mandatory basis is a specific, locally, participated, shared, and tailored legislation. In fact, the building codes have a local influence and represent the most effective tool to guide designers with the highest level of detail. Such locally based instructions are expected to have a much greater influence than unspecific national laws.

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