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CONTRIBUTION OF SUSTAINABLE BUILDING TO MEET EU 20-20-20 TARGETS

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The integration of sustainable solutions in Portuguese old building architecture

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ABSTRACT: The low energy renovation of historical buildings is always a challenge for professionals. The recast EPBD allows the member states not to apply great part of its requirements to these kind of buildings and this has been not considered fundamental in building energy-renovation policies. This research aims to make an overview of possible sustainable and low energy solutions for these buildings as well as intend to focus on how deep these solutions has been implemented so far on Portuguese building renovation projects. Seven case studies, supported by the analysis of seven renovation design projects, were conducted, complemented by in-deep expert interviews. This study shed more light to the fact that it is possible to integrate these solutions and also that it is not common to adopt them in old building renovations. This study make obvious that there is an increasing awareness of professionals involved about the importance of this issue.

1 INTRODUCTION

There is a growing recognition of the architectural and cultural value of buildings in historic city centers. Gradually governments recognize the contribution that built cultural heritage makes to the social well-being of different groups living in villages and cities (Tweed & Sutherland 2007). However, there are a great number of abandoned old buildings in many city centers. Portugal, unfortunately, has many of these examples. The historic city centers problems and the barriers to its renovation are thoroughly known. The visible level of deterioration, the decrease of building indoor habitability conditions and the real estate speculation are examples. Portuguese social and urban planning policies and regulations have been over the years less focused on the increase of the building renovation but more directed to new buildings. So far, governments did not offer the sufficient policy tools to encourage the maintenance of privately owned historic buildings. Nevertheless, there are some signs of a growing interest on historic centers by some specific social groups, as for example, university students and young couples. According to Queirós (2009) the historic city centers provide uncountable benefits and opportunities, since they can be enjoyable living places in an historic and cultural environment, have a strong potential for tourism activities, can be attractive both commercial and services areas and can offer local employment opportunities, thus helping local economy. Teller & Bond (2002) considers that is crucial to found new socio-economic uses for heritage buildings areas, in order to maintain them in sustainable activity cycles.

On the other hand, sustainable buildings became nowadays the key to addressing multiple challenges despite much of the focus so far has been mainly on energy efficient issues. Meijer et al. (2009) considers that existing building stock will continue to dominate for the next years and its sustainable renovation is needed mainly for its energy-saving potential. But in an holistic point of view, the renovation of old buildings should embrace energy efficiency, low carbon emissions, harmonized relationship with the surrounding environment, cost effectiveness, economic viability, and social equity and cultural identity (Yung & Chan, 2012).

2 SCOPE AND METHODOLOGY

The focus of this paper, as a part of a wide research titled "Renovation management in urban historic centers", is to give an evidence-based image of how deeply the subjects related with sustainability, energy efficiency and bioclimatic solutions are been implemented in the Portuguese old building renovation design projects. At the same time, possible sustainable and low energy solutions are proposed.

In order to reach the aim of this study, a literature review on scientific literature, political documents, national and international reports and data bases was held. Following, this research was divided in two different phases and two different data sources, in order to ensure well-founded and reliable data. An analysis of seven case studies was the first step. Seven different building renovation design projects, were reviewed and object of a comparative analysis. Only one of the seven design projects was near to be complete and there was missing data in most of them due to the fact that not all parts/specialties of the design project were available. Due to the lack of information on the design projects and for achieve more accurate data, expert interviews to a group of selected stakeholders were held. The interviews involved Portuguese architects and civil engineers. The interviewers work mainly in design project activities, construction management and supervision of old building renovation. The possible answers to the questions were "YES" or "NO" and additionally they could write some comments. It was only possible to make fifteen interviews in a group of forty potential stakeholders because twenty five did not reply.

3 MAIN CHARACTERISTICS OF BUILDING STOCK AND RENOVATION CONCEPTS

3.1 *Historical and old building stock data*

European statistics reveals that 14% of European building-stock dates before 1919 and 12% between 1919 and 1945 (Euroconstruct 2013). According to the most recent available data from INE (2013), Portugal has 5 878 756 accommodations in a total of 3 518 152 buildings. Old buildings, built before the year 1945, represent 14,4% of the Portuguese building stock. The Table 1 represents a relation between these type of buildings and their repair needs.

Table 1. Relation between buildings age and repair needs

Construction time (age)	Before 1919		Between 1919 and 1945	
Buildings numbers and percentages	N.º	%	N.º	%
Without repair needs	77.326	2,18	125.924	3,55
With repair needs	106.616	3,01	162.017	4,57
Very degraded	22.381	0,63	17.755	0,5
Total	206.343	5,82	305.696	8,62

It is estimated that 10,6% of Portuguese existing building stock built before 1945 does not have concrete structure. From a total of 305 696 old buildings built between 1919 and 1945, 135 596 have concrete structure and masonry walls with concrete slabs. There are 268 633 old buildings (7,58%) built before 1945 with repair needs and there are 40 136 buildings (1,13%) with a high level of degradation. In total there are 308 769 old buildings with renovation needs, which is 8,71% of total Portuguese existing building stock. On energy use matters, Meijer et al. (2009) found that in most buildings statistics it is usually to found no data available.

3.2 *Sustainability and energy efficiency as recommendations for building renovation*

According to the ISO 13822:2010 (2010), the sustainable construction principles are applied when existing materials and structures can be reutilized, instead of replaced by new ones, following building life cycle principles. The sustainability and energy efficiency issues are included in the agenda of many European governments and therefore it is nowadays common to found these issues as a part of many regulations, policy documents and several associations documents and reports.

According to Plessis (2002) the sustainable practices could be more expressive using the following construction sustainable principles, published in the First World Conference About Sustainable Construction (Kibert 1994), such as: minimize resources consumption; maximize re-

sources reutilization; use renewable and recycled resources; protect natural environment; create health and not toxic environment and develop quality comfort in the built environment.

Addressing the latest Portuguese Law 32 (2012) that regulates Portuguese urban and planning renovation activities it is evidence-based the concern about sustainability. This legal framework refers that is important to: promote buildings energy efficiency; improve habitability, functionality and comfort indoor conditions; bring up to date infrastructures and regenerate city gardens; develop conditions to walk and increment the bicycle transport use; protect cultural historic and heritage as identity and culture value and promote the environmental, social and economic sustainability in urban areas.

The ICOMOS (International Council on Monuments and Sites) (2003) also propose technical recommendations and guidelines to adopt particularly in old buildings and heritage protected areas. The most relevant are: make preliminary studies of the building conservation level; reduce the intervention impact to maximum and focus on the replacement of deteriorated parts; identify the problems and define potential solutions; make the compatibility between new and existing materials; promote the reversibility and maintain the original constructive techniques; improve the energy performance and comfort levels; develop water reduce consumptions and energy efficiency solutions; respect the building life cycle and promote maintenance and conservation policies; preserve elements with recognized cultural and historic interest; prefer deconstruction techniques in case of demolition and identify the problems and constraints to reduce risks and unexpected situations.

3.3 *An overview of sustainability strategies on building conservation and renovation*

Renovating an old and historical building is a demanding challenge for professionals. Fielden (2003) refers seven different levels of action in an old building: deterioration prevention, preservation, consolidation, restoration, rehabilitation, reproduction and reconstruction. According to Paiva (2006) the renovation can comprise simple tasks as paintings, small repairs, modification of indoor space functions and demolition of some simple building parts or be more complex, such as, reconstruction or restoration. A well-done preliminary diagnosis is a crucial support instrument for the correct decision. The ICOMOS (2003) define historical buildings renovation as the "*process to bring a building to a new use or function, without change the portions of the building that are significant to its historical value*". These practice represents an opportunity to make possible a contemporary use of the buildings. This activity require specific and multidisciplinary knowledge, which success depends on a coordinated and efficient management effort between conservation, technical and urban development professionals and experts. Today, some authors use the term adaptive reuse of buildings. "*It is a form of sustainable urban regeneration, as it extends the building's life and avoids demolition waste, encourages reuses of the embodied energy and also provides significant social and economic benefits*". (Yung & Chan, 2012). Adaptive reuse of historic buildings has increasingly emerged in urban conservation, in particular in the developing countries however it is more difficult than the reuse of ordinary buildings because need to have minimal impact on the building heritage value. Santoli (2003) refers that building maintenance and restoration are an important contribution to sustainability. This author is from the opinion that "*the production and the use of energy using high efficiency strategies, when appropriately developed, may represent an important tool for the protection and conservation of the cultural heritage*". He also believes that this attitude makes possible the successful integration of technological solutions and the improvement of the conservation conditions, considering energy efficiency as the proper tool to be used in the conservation of cultural heritage. Nevertheless, there are heritage consultants that point out that conservation principles are the prime concern and that environmental performance criteria is not the most important consideration in the renovation of built heritage (Yung & Chan 2012).

Nonetheless, the recast Energy Performance Building Directive allows the member states not to apply the requirements to buildings and monuments officially protected or having an architectural or historic value or even being part of a particular environment if this could alter their identity and appearance. In result of that, the predisposition of the stakeholders involved is normally not to apply low energy solutions to this group of buildings because they not feel it is mandatory. One important thing to underline is that many old buildings use vernacular architecture. This means that they make use of one or another passive principles adapted to the local

climate but this is usually not enough to get more close to the energy efficiency levels of new buildings.

After this considerations, the question is: it is reasonable to invest in the energy renovation of historic buildings? Troi (2011) considers that finding conservation-compatible solutions for the energy renovations of historic buildings enhances long-term-conservation and sustainable management of these buildings and urban centers. This author estimated that old buildings energy renovation in the EU-27 can save 180 Mt CO2 within 2050. Although it is a major challenge to renovate energy-inefficient old buildings to lower energy consumption attending its very specific demands it offers better thermal comfort and increase property value. There are some European countries were this started to be a current practice some years ago and where some ongoing projects, that include experts, industry partners and stakeholder associations, are developing passive and active energy-renovation solutions for historic and old buildings (Troi & Lollini 2011).

3.4 *Barriers to building renovation*

As in renovation in general, the specific market of conservation and renovation of old buildings faces particular barriers. The complex renovation of these buildings have, until today, contributed to the building of a barrier between professionals active in the field (Santoli, 2003).

For Portugal, Coias (2007) identified the following barriers: heritage protection is not sufficiently recognized by the governments and institutional bodies as an identity of the country culture; there are reduced knowledge and practices of conservation and maintenance; there is lack of tailored laws and policies, mainly for financing these activities; there are insufficient competencies of project designers; there is a widespread idea that new construction is easier then renovation and that gives a better cost-benefit relation; many situations observed demonstrate a lack of qualified professionals to implement sustainable solutions and lack of adequate know-how on traditional construction techniques and finally there are not sufficient R&D on this field.

At an European level, studies (Meijer 2009, BPIE 2011) confirm as barriers the lack of knowledge and experience, the not convincing cost-benefit relation for the investor, the inappropriate products that are geared mostly towards new construction and few best-practice examples.

4 THE INTEGRATIONS OF SUSTAINABLE SOLUTIONS IN OLD BUILDINGS

4.1 *Sustainable and energy- renovation building solutions*

It is recognized that the construction technologies for renovation are relatively new and, unfortunately, most R&D and products development is directed toward new construction. The growing tendency of the building renovation market probably will stimulate, in a near future, the development of new products, that can also be used in historic buildings. According to Kibert (2005) there are some sustainable solutions that are possible to apply (Tables 2 and 3).

Table 2. Possible building sustainable solutions for renovation

Solutions	Description
Passive heating systems	- It is possible to apply individual or collective passive solar technologies however there are some existing elements that acts as barriers (Table 3).
Passive cooling systems	- Possibility to implement air admission vents and air remove vents in windows and roofs (at a higher level and in the opposite side).
Lighting	- An effective architectural study must be done to find the best solutions for natural daylight using existent windows, open spaces, light colors, light tunnels and others. Adoption of more efficient artificial lighting systems: LED, automatic switches, temporized lamps is also a strategy.
Construction Materials	- Some elements must be preserved and deteriorated ones must be replaced by similar ones. The new materials should: promote reversibility; deconstruction; contain recycled composition and other environmental standards during life cycle (low water and energy consumption and reduced CO_2 emissions levels in the manufacturing, transport, maintenance and recycling) and be produced near from the local of application.
Constructive technologies	- The existing building technologies must be preserved and protected. This action can promote: reduction of materials and construction resources; reduced amount of construction and demolition waste; budget savings and more building authenticity preservation.

Table 3. Possible building sustainable solutions for renovation

Solutions	Description
Land use	- Building renovation happens in urban consolidated areas and uses local infrastructures and therefore helps to preserve virgin soils.
Water consumption	- It is important to reuse water (rain water and gray water) to use on gardens and to flush toilet waste. Reduce the pressure levels, re-arrange the piping system and install other efficient equipments (water reduction taps, automatic and thermostatic taps) are also good strategies.
Energy	- The energy efficiency can be achieved by applying: photovoltaic panels on roofs (which, if possible, should not be visible from the street); an energy certification process to promote the compatibility between existing and new solutions with the preservation of cultural and historical elements and solar collectors for DWH.
Monitoring and maintenance	- The energy and water consumptions should be monitored with appropriate systems following a maintenance plan.
User's guide	- There should be a building user's guide.
Sustainable certification	- Sustainable certification can be done by assessing other sustainable methods (Leed, Breeam, SbTool, LiderA, etc) were the sustainability levels depend on the sustainable solutions adopted.

With the propose of reaching similar energy performance requirements as those established for new buildings, it is possible to adopt in old buildings a range of passive and active energy-renovation-solutions. The implementation of the solutions mentioned above in old buildings needs interdisciplinary cooperation and supplementary effort because normally standard solutions cannot be used. Constraints and building architectural character must be studied carefully and the option for reversible solutions are a kind of important practice that helps to preserve building identity.

The Tables 4 and 5 disclose passive solar solutions according to Steven Winter Associates (1997) which have applicability and are compatible with old buildings architecture.

Table 4. Solar passive solutions compatible with old buildings architecture

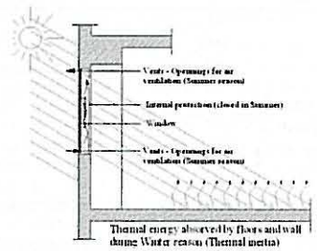
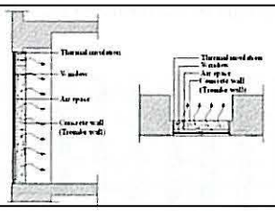
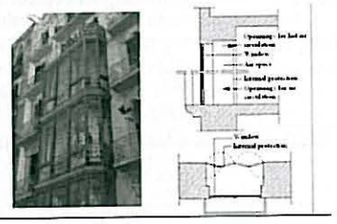
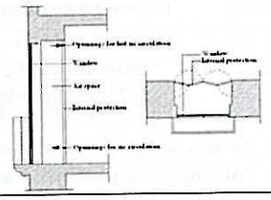
System	Descriptions	Figure
Direct gains	- Possible to apply but it has some constraints (orientation, dimensions, shading and others). - Solar radiation go directly through glass and heats the building internal elements (floors and walls). - In winter the movable insulation is open during the day to allow heating store in floors and walls and closed at night. - With south orientation it is advisable to cover windows and doors during summer with shading devices or movable insulation, which sometimes is difficult to compatible with the preservation of existing building solutions. - In summer is possible to use internal movable insulation, ensuring air circulation between this device and the window.	
Thermal storage wall (Trombe wall)	- During winter is possible to collect and store heat during the day to be transferred gradually to the indoor space, heating the room. - South orientation behind a window or a door is the best practice. Protection with solar shading systems or another insulation is important. - The integration is possible in existing windows or doors that are not usually opened, preserving existing materials and outside appearance.	

Table 5. Solar passive solutions compatible with old buildings architecture

System	Descriptions	Figures
Attached sunspace	- Good solution for the storage, distribution and control of thermal energy during the heating season. - There are some examples in vernacular architecture and it is possible to adapt contemporaneous solutions to old buildings: sunspaces, bow windows and others.	
Convective loop	- The thermosyphon effect transfers the heated air in the channel again to the indoor space by an upper opening. - During the night is necessary to insulate the windows and close the openings. - Easier solution for applying in existing windows which preserve their original function and appearance by the outside.	

5 THE SUSTAINABILITY IMPLEMENTATION IN THE PORTUGUESE OLD BUILDING RENOVATION DESIGN PROJECTS

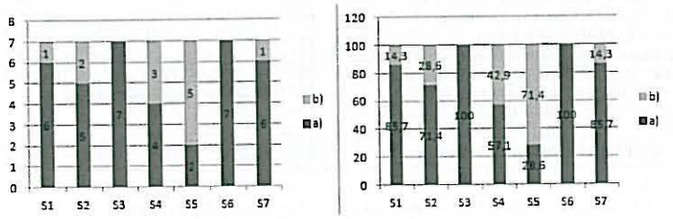
5.1 *Building renovation design projects analysis*

Seven different topics were selected for the analysis of the renovation design projects (Table 6).

Table 6. Topics - Design Project Analysis - Sustainable solutions implementation

Index	N.	Topics	
Sustainable solutions implementation	S1	Water reuse	- Water reuse systems
	S2	Solar collectors Domestic Hot Water	- Solar collector systems for DHW
	S3	Electrical energy production	- Microgeneration: photovoltaic panels and wind turbines
	S4	Energy efficiency - Thermal performance	- Thermal regulations requirements
	S5	Energy efficiency - Complementary solutions	- Natural daylight, ventilators, LED lamps, heating systems with biomass, natural gas, geothermal
	S6	Bioclimatic solutions	- Trombe walls, solariums/sunspaces
	S7	Other sustainable solutions	- Natural ventilation, green roofs, vegetation barriers for wind protection

A resume of the results of the design projects analysis is presented in Figure 1.



- a) – Design project without any reference to sustainable solutions;
- b) – Design project with references to sustainable solutions;

Figure 1: Results of the renovation design projects analysis - sustainable solutions implementation

The building renovation design projects reviewed have not any reference to "Electrical energy production" and "Bioclimatic solutions". Building solutions associated with "Water reuse"

and "Other sustainable solutions" appears in only one design project. Five of the seven projects design did not use "Solar collectors DWH". The requirements on the "Energy efficiency - Thermal performance" were considered in three of the total seven design projects. By the other side, solutions related with "Energy efficiency – Complementary solutions", more in line with equipments and mechanical systems, were used in five design projects. One question can be made. Why there is a great number of design projects without any type of implementation of sustainable, bioclimatic and energy efficient solutions? Firstly, the sustainability issue is a relatively new concern. Secondly, one of the design projects is from 2001, two of them from the year 2011 and the remaining four from 2007 thus only two of the projects are relatively recent and even in the most recent design projects the reduced allusion to sustainable solutions was registered.

5.2 *In-deep interviews to stakeholders*

Due to the lack of some important information for research after the design projects analysis and for achieve more accurate data, it were made expert interviews to a group of selected stakeholders (Table 7). The interview's main focus was in three of the topics.

The core questions, the results and the more relevant conclusions are in Table 8.

Table 7. Topics - Expert interviews

N.	Topics	Data source
S1	Water reuse	Interview – Question 1
S2	Solar collectors DWH	Thermal design project
S3	Electric energy production	Electrical design project
S4	Energetic efficiency - Thermal performance	Thermal design project
S5	Energetic efficiency – Complementary solutions	Electrical design project
S6	Bioclimatic solutions	Interview – Questions 2 and 3
S7	Other sustainable solutions	Interview – Questions 2 and 3

Table 8. Interviews: Questions, results and conclusions

N.	Question	Results and conclusions
Q1	- Do you consider advantageous to implement water reuse solutions on design project, like automatic and thermostatic taps and rain water and/or gray water reuse?	- Answers: 93,3% YES and 6,7% NO. - There is no doubt about the interest to implement water reuse solutions which contributes to a more sustainable environmental approach for the buildings.
Q2 and Q3	- Do you consider difficult to implement in historic centers buildings bioclimatic solutions and other sustainable solutions different than conventional ones? - Do you think is important in building renovation to considerer sustainable and bioclimatic design solutions?	- Answers to Q2: 53,3% YES, 40% NO and 6,7% without any answer. Answers to Q3: 100% YES. - The majority of the interviewed consider the fact that being historic buildings represents a constraint to implement bioclimatic solutions (Question 2). - By the other side, all stakeholders consider unquestionable to apply these solutions in building renovation design projects (Question 3).

6 CONCLUSIONS

The renovation of the historic centers and its buildings could be the opportunity to apply sustainable practices. Old buildings need conservation, indoor comfort and better energy performance to reach the functionalities required by the modern societies way of living. The studies made so far consider that historic architecture can often be adapted to meet modern requirements without losing heritage value and also that is one of the important strategies to reduce carbon emissions. It is possible to implement sustainable and energy efficient solutions keeping social, historical and cultural identity despite this requires specific technical knowledge from the professionals involved.

The analysis of the building renovation design projects demonstrated that it is not common to adopt an energy efficient renovation approach in Portuguese historic and old building renovation design projects. The documents analyzed revealed interesting building solutions although

most common building solutions registered were not so different of conventional ones. The analysis made shed more light to the fact that it would be possible to implement even better and more sustainable practices and therefore get more close to the energy efficiency levels of the new buildings.

The study have demonstrated that despite the majority of the professionals consider the historic context of these buildings as a barrier there is an evident awareness of architects and civil engineers that is important to search for more know-how and training to implement sustainable, bioclimatic and energy efficient solutions in these type of buildings. However, they are also from the opinion that it is possible to adapt these solutions but it is fundamental follow a multidisciplinary approach between stakeholders, overcoming the gap between innovation and conservation or renovation.

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