

# Balancing cultural and environmental values in buildings refurbishment

## Assessing integrity and energy

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**Abstract** – Considering the current challenge of environmental efficiency, urban policies should aim to improve existent buildings' environmental performance by improving their energy performance. Building energy refurbishment solutions should also be weighed against the preservation of the building's integrity and cultural value. This paper discusses criteria for the assessment of the impacts of urban buildings refurbishment, considering the risks and opportunities for both their cultural values and environmental resources.

After a brief review of the operational concepts and the technical and policy references, the paper presents an assessment grid, developed in the framework of the research project "Decarbonizing Cities: assessing urban and building rehabilitation impacts on urban metabolism and heritage", focusing on the trade-off between cultural integrity and embodied energy preservation. Two case studies are presented to illustrate the use of the assessment grid.

**Keywords** – urban buildings' refurbishment; heritage cultural values; environmental resources efficiency

## 1. INTRODUCTION

The inherited urban building stock that makes up for most of our European cities, is a valuable societal asset that by far exceeds the individual building's market value. This building stock is the result of a long additive process through time, embodying both material and immaterial resources and values that no society can afford to disregard and waste. Refurbishing and improving on this building stock is thus a common-sense approach. In line with these ideas, building refurbishment and urban regeneration have become major priorities in Portuguese urban policy, succeeding over six decades of urban sprawl and lesser attention to the existing city. Combined with renewed attention to energy efficiency, this change of direction in urban policy is not free from difficulties. Under the general notion of refurbishment, different approaches to the existing building stock are coexisting, many of them resulting in an actual loss of value, both cultural and environmental, even if the objective of increased operational energy efficiency is achieved.

This paper is based on preliminary results from the research project "Decarbonising Cities: assessing urban and building rehabilitation impacts on urban metabolism and heritage", designed to develop operational tools and

criteria to conciliate cultural values and environmental resources efficiency when implementing policies. It presents a scoring grid designed to estimate impacts in building refurbishment (chapters 4 and 5) and a brief review of concepts and references (chapters 2 and 3).

## **2. SOME OPERATIONAL CONCEPTS**

### **2.1 CULTURAL VALUE VS ENVIRONMENTAL EFFICIENCY**

Conserving *environmental resources* in buildings can help to preserve *cultural values* [1]. However, these aspects tend to be perceived and managed separately: cultural heritage assessment addresses immaterial values, such as authenticity, significance or integrity, while environmental assessment addresses resources, such as operational and embodied energy.

### **2.2 URBAN BUILDING STOCK CULTURAL VALUE**

#### **(a) Integrity**

*Integrity* is defined in the European standard EN 16883 [2] as *the extent of physical or conceptual wholeness of a building*. Integrity represents also the matching between a building and the original societal context in which it was built, considering the technical resources and aesthetical standards of that time. Levels of integrity have been considered as a material dimension of the built heritage, despite representing also immaterial dimensions.

#### **(b) Authenticity**

*Authenticity* is defined in EN 16883 [2] as *the extent to which the identity of a building matches the one ascribed to it*. It refers to a correspondence between a way of living and production, in a certain place and time, and the building as it is now. It can be a criterion for selective conservation but it should not hamper the modernisation interventions in buildings, with their own authenticity. Following the ICOMOS Nara document on authenticity, a grid for building elements validation was defined [5]. This grid does however not consider the addition of new levels of authenticity by new interventions in buildings.

#### **(c) Significance**

*Significance* is defined in EN 16883 [2] as *the combination of all the heritage values assigned to a building and its setting*. Despite being frequently used to analyse listed heritage by UNESCO or ICOMOS, “*there is probably no simple or comprehensive set of rules by which this significance can be valued*” [6]. In urban built heritage, significance assessment is multi-dimensional. Some authors assess significance in a quantitative way, through the identification of character-defining elements and of the way interventions impact on it [7].

### **2.3 URBAN BUILDING STOCK ENVIRONMENTAL EFFICIENCY**

Assessment of the urban building stock environmental efficiency aims to measure natural resources consumption to achieve a certain performance, contributing to predict life cycle environmental impacts. It relies on industrial ecology methodo-

logies such as Life Cycle Analysis (LCA) which comprises production, operation in-use and end of life phases of products. LCA can also be applied to the urban building stock. This methodology addresses environmental resources as raw materials, water, ecosystems, climate change, but it can focus only on energy (Life Cycle Energy Assessment–LCEA). In LCEA impacts are measured in primary energy and CO<sub>2</sub> emissions.

**(a) Operational energy**

The amount of energy demanded to meet the requirements of a building in-use is called *operational energy*. The building functions, which have substantial operational energy demands, concern mainly environmental comfort: heating, cooling, ventilation and lighting. Bioclimatic-sensitive architecture can reduce operational energy demand for environmental comfort at a low cost. Renewable energy and energy efficiency technologies can also reduce it, at a higher investment cost. Operational energy demand is also dependent from user behaviour.

Conflicts between winter and summer operational energy needs are identified as a barrier to the definition of optimal operational energy reduction measures [8]. In southern Europe climate, construction traditions and social factors, which justify a low energy demand for comfort, are not always being considered, leading to an overestimation of energy consumption.

**(b) Embodied Energy and LCEA**

The *embodied energy* corresponds to the energy spent in the materials and processes implied in the production and refurbishment of the building stock. Regarding buildings, it is common to refer the proportion of 20 percent of embodied energy to 80 percent of operational energy. However, these values refer to overestimated consumptions, exclude refurbishment embodied energy additions trough time, do not consider the whole cycle and neglect the traditional buildings high embodied energy [1]. Measures aimed to reduce operational energy may lead to an increase of embodied energy due to demolition and waste disposal of old materials, and due to transportation and incorporation of new materials [10].

LCEA adds to *operational energy* the *embodied energy* related to construction materials and processes, offering a comprehensive approach to environmental efficiency of the building stock [11]. In general, LCEA relies on data bases that do not include embodied energy in traditional pre-industrial materials and processes, since such measuring requires complex historical research.

### **3. REFERENCES ON BUILDING REFURBISHMENT IMPACTS ASSESSMENT**

#### **3.1 TECHNICAL REFERENCES**

The *European Guidelines for Improving the Energy Performance of Historic Buildings* (EN 16883: 2017) [2] aim to achieve a sustainable balance between the use of a building, its energy performance and its preservation and conservation, assisting in the choice of the most appropriate energy efficiency measures. This European standard envisions actions aimed strictly to improve energy

performance. Current urban building stock refurbishment, with no direct energy efficiency purpose, is not considered.

According to EN 16883, the condition of the building envelope and technical systems shall be surveyed, repaired and optimized before considering improving energy performance. User behaviour as a factor of energy consumption shall also be observed. Only after this, a decision shall be made on the need of improving energy performance through specific measures.

The building survey shall describe: i) heritage significance and conservation opportunities and constraints; ii) past and present uses; iii) structural system; iv) energy performance assessment; and, v) indoor environmental assessment. The standard refers to other standards (EN 15603) for tailored energy performance assessment of existing buildings, not advising the use of the same methodology for the pre-existence and after refurbishment.

The categories used by the standard to select the best energy efficiency measures (concerning the building envelope, the technical systems and user behaviour) are: i) technical compatibility with the existing structural, constructional and technical systems, referring to risks and reversibility levels; ii) heritage significance, including physical and design integrity; iii) economic viability; iv) energy, including operational energy demand and embodied energy, v) indoor environmental quality; vi) outdoor environment; and, vii) use.

The standard presents an example of an assessment table to be applied, measure by measure, in each of these categories (Annex B). This example is suitable for the evaluation of energy performance improvement measures. However, since energy performance is not always the main driver of building refurbishment, this example is not suitable for the evaluation of the impact of general refurbishment works on energy performance.

The procedure set by EN 16883 includes heritage cultural significance criteria (see 2.1) and operational and embodied energy criteria. It does not include urban integrity and architectural integrity as specific criteria, encompassing them in “physical and design integrity”, which shall be evaluated in terms of material, visual and spatial impact. It also does not contain its own guidelines for operational energy simulation, forwarding to EN 16096, EN 15603 and EN 16247. Concerning embodied energy, it refers to EN 15643–2, a standard regarding new buildings and materials, lacking specific information for pre-industrial construction.

Contemporary to the development of EN 16883, “*Energy Efficiency in European Historic Urban Districts*” (EFFESUS) [12] was an innovative project which produced public reports and a Decision Support System (DSS) and software with impact assessment modules matching the assessment categories of EN 16883. The DSS requires location-specific information and technical data, which are not location-specific, such as retrofit measures.

While location-specific data allow the consideration of local climate aspects, the not site-specific repositories of measures can result in a lesser consideration of

specific cultural and constructive aspects (e.g., the role of stone and mortar and vapour-open construction techniques in comfort [13], [14]). EFFESUS developed repositories containing measures to retrofit building fabric and technical building services (e.g. conventional insulating systems; slim-profile insulating systems; insulating coatings) and to decarbonise the energy supply (e.g. solar photovoltaics for pitched roofs) [12], [15]. Rodwell and Hermann [7] evaluated the impacts of these measures on heritage significance and character-defining elements, providing a balancing procedure that, despite being conceived for energy retrofits, can be adapted to refurbishment operations with no direct energy efficiency purposes.

### **3.2 POLICY REFERENCES**

The development and publication of EN 16883 is contemporary of European policies on heritage conservation, such as the European Cultural Heritage Strategy for the 21<sup>st</sup> Century (2017), the report Cultural Heritage Counts for Europe (2015) and the recent initiative of the European Commission to make 2018 the European Year of Cultural Heritage. The European Cultural Heritage Strategy for the 21<sup>st</sup> Century presents recommendations to protect, restore and enhance heritage, making use of new technologies and to develop knowledge banks on local and traditional materials, techniques and know-how.

These endorsements, on new technologies and on traditional know-how, are not equally considered in EN 16883, since the standard focus mostly on enhancing heritage, making use of new technologies for operational energy demand, while focusing less on embodied energy and passive performance, which can be achieved by better knowledge on traditional construction.

Recently, packages of measures of building “energy refurbishment” emerged with ecological purposes at the scope of the International Energy Agency [17] and the Intelligent Energy European Programme of the European Union (NZEB and SZEB initiatives). In most cases these initiatives were aimed at the post-war social housing stock and do not predict ways to regulate intervention in pre-industrial of buildings.

Mainstream energy refurbishment measures consist of increasing thermal insulation and air tightness of the building envelope aiming to reduce energy consumption. Cost-efficiency, performance of active systems and integration of renewables are key issues. However, this kind of energy refurbishment, even following certification schemes, does not always result in energy savings (as the methodologies used do not consider passive environmental performance and do not suit older buildings and mild climates in southern Europe [18], [19]). User behaviour, adaptive comfort and energy prices are also not always considered in the assessment of energy refurbishment packages.

## **4. A FRAMEWORK FOR REFURBISHMENT IMPACTS ASSESSMENT**

### **4.1 BUILDING AN ASSESSMENT GRID**

The mainstream concept of *building energy refurbishment* addresses operational energy performance as a factor prevailing over others. However, during its long

lifespan, the urban building stock collects cultural values and other environmental resources, which are inseparable. Comprehensive assessment tools and methods, able to take into consideration both cultural values and life cycle environmental resources in a related way, are thus needed. With this purpose, based on the reference framework outlined in chapters 2 and 3, an assessment grid was developed, relating two sets of analytical dimensions: the building's urban context, architectural features and environmental attributes, to different types of interventions in buildings (Table 1).

Three urban context factors are considered in the assessment grid: (1) *urban morphology 2D* – plot structure and street pattern; (2) *urban morphology 3D* – volume, considering the original characteristics of the building and of adjacent buildings; (3) *public space interface* – building contact with adjacent public space, in general at the ground floor.

Four architectural features are considered; (4) *type of construction* – structural system and primary construction elements; (5) *architectural typology* – spatial organization and secondary elements; (6) *social use* – the original activities the building was built for and their relation to the new use of the building; and (7) *character defining elements* – elements that contribute to the *heritage significance* and to the building's identity.

Eight environmental attributes are considered: (8) *high embodied energy materials* – a selection of materials, mainly structural, which have high energy value, and thus should not be lost (9); *passive operational performance elements* respecting thermal and environmental comfort (10 to 14); and *active energy systems* (15) for energy saving through technical equipment (central heating, solar hot water, solar PV, HAVAC).

At the other grid axis, six different types of interventions in buildings are considered: i) *full preservation*, where the building is returned to its original state, when known; ii) *high preservation and optimization*, where the building suffers minimal interventions for improving functional and/or environmental performance, mostly on the envelope; iii) *medium preservation and optimization*, where the building suffers a deeper intervention, namely structural reinforcement, technical facilities replacement and/or changes in inner lay-out; iv) *partial preservation plus extension/addition*, where the building is enlarged in height, depth or width; v) *low preservation and reconstruction* (e.g., façade preservation only); vi) *no preservation/total reconstruction*, where the building is demolished and replaced (even if by a mimetic construction).

Each cell in the grid is scored using the five categories found in Annex B of EN 16883, from high risk (--) to high benefit (++). Scoring criteria is still under development in the research project. Scoring shown in Table 1 is related to the case studies (see chapter 4.2). The table can be used as a scorecard when applied to refurbishment operations. The grid is applicable not only to energy refurbishment but also to other interventions on buildings which have impacts also in energy and environmental performance. As for the EN 16883 assessment table, this grid should be applied after the building survey has identified

pre-existing values and conditions. The grid can be applied even when the building does not need energy improvements.

Table 1 – Assessment grid and impact scoring

Urban context, architectural features and environmental attributes		Types of interventions in buildings					
		I	II	III	IV	V	VI
1	Urban morphology 2D	++			+		
2	Urban morphology 3D		+		-		
3	Public space interface	++					--
4	Type of construction	+		-	/		--
5	Architectural typology				+		-
6	Social use		+		+		
7	Character defining elements	++				--	
8	High embodied energy materials	++					--
9	Waste	++					--
10	Thermal inertia	++			-		--
11	Solar control		+		+		--
12	Vapour open/Air tightness	++			/		--
13	Natural ventilation		++			/	
14	Insulation	-			+		+
15	Active energy systems				+		++

#### 4.2 TESTING THE GRID

To test the assessment grid, two case studies were selected, located in a central Lisbon residential district. Both were recently refurbished, though with different approaches. Case study A is a residential building erected in the late 1700's using the then traditional techniques common in Lisbon (coarse stone and lime mortar for outer walls and timber for floors, partitions and roof). The plot was part of a subdivision of land based on the square grid. The pre-existing building was preserved and one floor was added.

Case study B is a residential building erected in the early 1900's using then current building techniques (brick walls and timber floors and roof). The plot is in the same area as case study A, with the same historical background. The pre-existing building was demolished and replaced by a new building.

Both original buildings presented some integrity, although the first had higher authenticity and significance, as an exemplar of the initial settlement in the area. The structural systems were in good condition, though affected by seismic vulnerability. Energy performance by the Portuguese certification system was low (F for case A and D for case B).

In case study A, levels of preservation of building elements range from I to IV (columns in Table 1). The scoring assigned (cells in light grey) for each feature



Figure 1. Images of the case study buildings before and after refurbishment. Photos: Joana Mourão.

from the grid (lines in Table 1) considered: the urban plot structure was preserved (1) but the building was extended in height (2). Ground floor interface was not changed (3). The original construction was preserved partially and reinforced, and a new light weight construction was added for the new floor and roof (4). The inner layout was kept, and use is the same as the original house (5, 6). Character defining elements (window stonework and inner stairs) were kept (7). High embodied energy structural materials were preserved (8) and waste was minimized (9). Passive performance was optimized and improved (10–13) and the roof was insulated (14). Water solar heating was added on the new rooftop (15).

In case study B levels of preservation of building elements range from II to V (columns in Table 1). The scoring assigned (cells in dark grey) for each feature from the grid (lines in Table 1) considered: the urban plot structure was preserved (1). The original volume was reproduced, with a recessed upper floor (2). The ground floor now includes a garage facing the street (3). The original construction was replaced (4) and an open-space inner layout was adopted in place of the previous partitioned layout (5), although the use is the same (6). Character defining elements were replaced by others that contrast with adjacent buildings (7). Embodied energy of the original building was lost as waste (8,9). Passive performance relies only on new windows and envelope insulation (10–14). Solar water and HAVAC were introduced for high standard environmental comfort (15).

Applying the grid to case study A, the impact score totals +19, which is 60 percent of maximum benefit (+30 score). For case study B the impact score totals –11, which is 40 percent of maximum risk (–30 score). These results are in line with the empirical assessment of the two cases in terms of urban, architectural and environmental performance:

- case study A shows that the addition of a floor can be compatible with the preservation of urban and architectural integrity and good environmental performance;
- case study B shows that replacing a building has significant risks for cultural values and environmental resources.



## 5. CONCLUSION

The grid presented in this paper is still a preliminary result of the research project. Ongoing research includes the analysis of urban and heritage policies in Europe and the assessment of policies and practices in Portugal. Validation of the grid with its scoring system, establishing the scoring criteria and adding a support grid for the assessment of the values and resources previously to the refurbishment, will require further development and testing. For that purpose, a suitable range of cases representing different approaches to urban building refurbishment and different building types will be selected and analysed.

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