Technical guidelines for energy efficiency interventions in buildings constructed before 1955 in Greece

E. Alexandrou¹, M. Katsaros¹, D. Aravantinos², K. Axarli², A. Chatzidimitriou², A. Gotoudis², Th. Theodosiou² and K. Tsikaloudaki²

¹ School of Architecture, National Technical University of Athens, (NTUA), Athens, Greece. Email: eealexandrou@gmail.com

² School of Architecture, Aristotle University of Thessaloniki, Thessaloniki, Greece.

Abstract – The Greek EPB regulation was recently reformed. During this procedure a scientific workgroup produced a series of Technical Guidelines for energy efficiency interventions in the existing building fabric constructed before 1955 (year of the 1st building code), in order to be implemented in the new legislation. These old buildings differ in architectural form and demonstrate diverse structural characteristics, construction materials and thermal properties. The main goal of the working group was to classify this building stock, in order to address a series of appropriate energy efficiency intervention guidelines, targeted to the specific characteristics of the buildings in each category. The guidelines focus on a sustainable restoration approach with minimal and selective low impact interventions that can be applied either during a large scale renovation project or in repairing specific building components, even in officially protected buildings without being necessarily compelled to comply with the minimum EPB requirements.

Keywords – energy efficiency; heritage value; building regulations; EPBD; preservation

1. INTRODUCTION

The building sector is among the most energy intensive and responsible for a substantial amount of CO₂ emissions. Moreover, it poses a significant impact on the environment, throughout its life cycle (construction, use and end of life) as a large amount of materials and nonrenewable resources is consumed. Sustainable environmental construction and use of buildings has become a necessity. The European directive on the energy performance of buildings 2010/31/EU (EPBD) was developed in order to set the requirements on the improvement of the energy efficiency of buildings. However, the regulations have been applied mainly in new constructions and much less on the existing building fabric. In addition, the EPBD does not meet the specificities of older buildings of traditional architecture [1] with significant potential for enhancing its energy efficiency, as EPBD’s requirements and procedures cannot ensure or preserve their architectural value, and in practice, these buildings are either excluded from upgrading its energy performance -as ‘listed building’- or enforced to change their original architectural features. ‘Listed buildings’ comprise only a small percentage of the old building
Energy Efficiency in Historic Buildings 2018

A large number among them, possess heritage value (historic, cultural, architectural) but are not protected by any preservation regulation. In Europe, 23 percent of the existing fabric was built before 1945 [2]. Preserving, upgrading and reusing this valuable building stock instead of replacing it, is a sustainable approach, as it saves energy and resources, while at the same time preserves the history of the built environment and sense of a place.

In Greece, the first regulation on the energy performance of buildings was adopted in 2010 and was reformed in 2017. As in other European countries, the old directive excluded listed buildings and protected monuments from energy efficient retrofitting. This was mainly done due to the fear that such interventions may distort or damage significant building characteristics and challenge their historic value. This is a realistic possibility, as knowledge and expertise on cultural heritage, thermal comfort and energy efficiency is constantly advancing. On the other hand, the numerous traditional and historic buildings that are not listed or protected may retain some cultural value that will be discounted upon restoration and energy improvement works. The paper discusses the work elaborated by the scientific group, that produced a series of Technical Guidelines on ‘energy efficiency interventions’ to traditional or historic buildings, that was implemented in the recast of the Greek regulation, focusing a) on the classification of the ‘existing building stock’ and b) to outline specific technical interventions corresponding to each category.

2. THE EXISTING BUILDING STOCK AND ENERGY REGULATION

2.1 EXISTING BUILDING STOCK

The existing building fabric in Greece, and especially the buildings built before 1955 (the year of entry into force of the 1st Greek Building Code), is characterized by great diversity. Buildings representing the country’s turbulent history are scattered in cities, suburban areas, settlements and in the countryside. They retain architectural and structural characteristics owed to local traditions along with foreign influences, especially those of the many cultures that occupied

![Figure 1. Examples of the Neoclassical, Eclectic and Interwar era. Photos: Eleni Alexandrou.](image-url)
the country and left remnants of their architecture and construction technology (Romans, Venetians, Ottomans, Western Europeans, etc.), Figure 1. As a result, Greece in its small geographic area, demonstrates a relatively rich structural and architectural fabric that needs to be identified, preserved for its historic value, and thus addressed accordingly prior to any ‘restoration and energy improvement project’.

A substantial number of the discussed urban fabric consists of the so-called ‘traditional’ buildings, due to the materials and construction methods used. These buildings may differ in architecture and articulation, but they are all constructed with stone, wood, mud and lime, all local natural materials that demonstrate particular physical, thermal and structural qualities. The majority of traditional buildings are located in traditional settlements or historic districts, most of which are officially protected (Figures 2a, 2b), but many others of the same typology and construction are found outside the settlement’s boundaries or in remote areas and thus do not fall under similar restrictions (Figure 2c). Finally, a group of the pre-1955 building stock comprises representatives of local architectural traditions, (vernacular, neoclassical, pre-industrial and of the interwar era) with remarkable elements that may interfere with energy retrofitting works.

2.2 DEVELOPMENT PROCESS AND METHODOLOGY

The purpose of the technical guidelines was to resolve issues on energy efficiency upgrades of buildings constructed before 1955 currently in use, or in the process of small or large-scale renovation, in order to be reused. The first step was to clarify the building typologies and the level of protection on each one of them, to find the most accurate classification, and address a series of appropriate energy efficiency intervention guidelines, targeted to the specific characteristics of the proposed building types in each category, aiming in preserving the character-defining elements of the building.

Buildings that are listed either as monuments, or as part of a designated environment (traditional settlements or historic districts), comprise of a variety of constructions, built under different historic and socioeconomic circumstances. As such they are hard to classify in order to dictate appropriate common solutions.
Even though they are excluded from the minimum energy performance requirements, they could be energy upgraded, even partially, with pointed low impact reversible interventions, under specific circumstances, regulation and audit, without compromising their inherent qualities and heritage value.

Traditional buildings though, and especially the ones found within settlements, are easier to classify, as they possess common building typologies, construction materials and techniques as well as particular architectural, structural and thermal characteristics. Their response to climatic conditions is very different from the contemporary building systems and thus cannot be treated with similar techniques for energy efficient interventions. Their adaptation to contemporary energy requirements is a very complex issue that needs to be addressed accordingly in order to preserve their thermal and structural qualities. The regulatory parameters that need to be examined in their case are orientation, climate, thermal and moisture properties, building geometry and use.

Buildings that are not officially protected by heritage legislation have no restrictions and should comply with EPB regulations when restored. Nevertheless, they contain the majority of the examined building stock and in most cases demonstrate differentiated structural and thermal properties compared to the ones constructed after 1955. Furthermore, a significant number of them may retain heritage significance, as they consist of particular examples of local architectural and construction traditions of the country and in many cases represent their period of construction. At present, there is a danger that restoration and energy improvements undertaken on such structures will take place under insufficient guidance of experts and probably no concern or knowledge on their character and intrinsic qualities, usually following the predominant construction techniques of a specific place. All of the above may result in misjudgments that may not improve the energy efficiency of a building, and may distort the structural and thermal balance or cause disfiguration, irreversible damage and even depreciation. Hence, there is a need for official guiding and training on such practices, in order to define upgrades compatible to the characteristics of such buildings that will preserve their qualities and value, and make them responsive to contemporary needs and requirements. Nevertheless, as the aforementioned stock consists of structures that differ in architecture and structural characteristics, there cannot be a common methodology for energy and thermal improvement interventions.

### 2.3 BUILDING CLASSIFICATION

The analysis and assessment of the pre-1955 building stock, as described above, concluded in five distinct categories in which buildings would be classified, based on their heritage value and construction characteristics. For every restoration and energy improvement project to be initiated, the building that is subject to energy improvements will be classified by the auditing agent (Designated local Architectural board or the Ministry of Culture), to one of the five categories indicated in Table 1, in order to determine the level of protection and allowed interventions. Before this step, a detailed survey should be completed based on
a recording log, in order to record and assess the existing condition prior to any intervention. The information needed is related to climatic zone, geometry of the natural and built environment around the building, use, architecture, historic and cultural value, level of protection (if any), detailed description of the building and its components (geometry, number of floors, orientation, construction history, building materials and bearing system), and finally an assessment of the existing thermal and energy performance.

- **K1**
  Buildings in this category are listed as ‘Monuments’ and are officially protected according to Greek Legislation 3028/02 and thus excluded from the requisite/obligation to comply with the minimum EPBD requirements during renovation. (GR L. 4122/13) [3].

- **K2**
  Buildings in this category are listed either by law provisions (GR L.4067/12), [4] or by the Ministry of Culture and are also excluded from the requisite/obligation to comply with the minimum EPB requirements during renovation (GR L. 4122/13). However, the technical guideline suggests, that particular low impact sustainable interventions could be applied in order to improve energy and thermal performance during restoration or renovation process. The interventions should in each case retain the special architectural, structural and thermal characteristics, and preserve its value.

- **K3**
  Buildings in this category are within the limits of Traditional Settlements, which are officially protected and thus also excluded from minimum EPB requirements. As in K2, low impact energy interventions are suggested. Special attention should be given to newly constructed (after 1955) buildings that retain, as directed by the law, the architectural characteristics originally found in the settlement but are constructed with contemporary means, and therefore need to fully comply with energy performance directives during construction or renovation.

- **K4**
  Buildings classified in this category may possess remarkable characteristics (architectural or structural) but are not listed as of in K1, K2 and K3, even though they represent local architectural traditions of Greece and thus may retain architectural, cultural and historic value. Before the initiation of any work, a ‘detailed
record file’ should be compiled to the submittals required by the building code for a pre-building permit for cases of contemporary interventions or renovations in buildings prior to 1955. Subsequently, the building may be classified in category K2 or K3. If it does not suit in any of these, but the board concludes on its architectural or cultural value as a representative example of a specific time in the building history of the country, the guidelines suggest specific interventions.

- K5

Buildings in this category have no significant architectural, cultural or historic value. As such, before any major renovation or energy improvement intervention, a detailed file should be submitted at the local Architectural Board for auditing and authorization. Minimum EPB requirements should be met.

3. TECHNICAL GUIDELINES

The technical guidelines present a toolkit of technical instructions for implementing construction works on the structural elements and the technical systems of a building, during the process of energy efficiency upgrade. The instructions are basically focused on a) improvement of the thermal performance of a building.

Table 2. Sample of the concise table on encoded interventions

<table>
<thead>
<tr>
<th>Building evaluation/audit</th>
<th>Building categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building characteristics/ possible interventions</td>
<td>K1</td>
</tr>
<tr>
<td>Cultural &amp; architectural value</td>
<td></td>
</tr>
<tr>
<td>Load bearing capacity</td>
<td></td>
</tr>
<tr>
<td>Soil condition</td>
<td></td>
</tr>
<tr>
<td>Technical papers</td>
<td></td>
</tr>
<tr>
<td>Energy performance</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Structural components/ thermal improvements</th>
<th>Energy efficiency obligation by each category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior walls</td>
<td>K1</td>
</tr>
<tr>
<td>Stone masonry</td>
<td></td>
</tr>
<tr>
<td>Brick masonry</td>
<td></td>
</tr>
<tr>
<td>Timber framed</td>
<td></td>
</tr>
<tr>
<td>Roofs</td>
<td></td>
</tr>
<tr>
<td>Floors</td>
<td></td>
</tr>
<tr>
<td>Interior walls</td>
<td></td>
</tr>
<tr>
<td>Openings</td>
<td></td>
</tr>
<tr>
<td>Shading systems</td>
<td></td>
</tr>
<tr>
<td>Mechanical systems</td>
<td></td>
</tr>
<tr>
<td>Passive systems</td>
<td></td>
</tr>
<tr>
<td>Renewables</td>
<td></td>
</tr>
</tbody>
</table>
component, or the whole building, b) integration of technical systems (EMP) or renewables, and c) environmental upgrade of the open spaces around the building.

A presentation of the construction systems and materials of each building component, such as wall types (stone or brick masonry, timber frame), roofs (flat or sloped), floors, internal walls or partitions and openings, regarding their thermal properties and their energy performance characteristics, is followed by a detailed description and pre-calculation of possible alternate interventions, targeted to the characteristics of each building category and for selected major building components, i.e. structural system, building shell (walls, floors, roofs, openings, etc.), building materials and methods of construction.

The diversity of the existing building fabric in relation to preservation policies and all other interrelated constraints that need to be equally valued, make decisions upon the accurate intervention measures, a very strenuous procedure. For that reason, all of the above interdisciplinary data was incorporated in a concise table, a sample of which is presented in Table 2, that indicates the encoded intervention guidelines, along with the building evaluation, audit and energy efficiency obligation for each building category.

For example, on the section of thermal improvements of structural components, the energy efficiency obligation for each category regarding the exterior walls (which is probably the most challenging), is as follows: For K1 and K2 and all wall types (stone, brick, timber framed), there is no obligation for thermal insulation or energy performance upgrade. On K2 and K3, buildings with plastered walls are obliged to comply with the U-values set by the EPB regulation. In cases where the walls bear no plaster on either the internal or external surface, application of thermal insulation on any of the two sides is examined. If, however, a justified and reasoned incapability to conform is submitted, there is no obligation for thermal insulation application. K5 should comply with minimum EPB requirements.

4. DISCUSSION

It is well known that the worst enemy of old buildings is depreciation and dereliction, as it leads to degradation and finally to irreversible destruction. Thus, they need to be upgraded and enhanced to respond to contemporary needs and energy requirements. The energy efficiency upgrades of historic buildings constitute a complex work, as many underlying issues need to be addressed. They demand a multidisciplinary approach, expert knowledge and proper guidance. Preservation regulations, on the other hand set even more limitations that often discourage restoration and energy improvement works. All of the above account for reluctance or bad practices regarding energy efficiency retrofitting improvement works during restoration. Finally, the most difficult matter is that historic buildings possess many attributes that contribute to their uniqueness. Each case may defy old practices.

Even though the scientific team completed the project prior to the release of CSN EN 16883:2017 [5], there are many similarities in the general approach as well
as in specific areas, such as the building survey and assessment. However, the biggest challenge and innovation on the Greek work was the classification of the pre-1955 existing building stock. The classification was developed to facilitate and guide all involved stakeholders, community planning administrators and government agencies on auditing and assessment procedures. In addition to that, the technical guidelines will be used as a helpful tool and advice for architects, conservators, as well as owners, in order to address successfully restoration and energy improvement works, with respect to the building’s inherent qualities and potential, place, climate and cultural values.

The Technical Guidelines for the energy efficiency retrofitting intervention on existing buildings constructed prior to 1955, have been released and after validation will be implemented in the recast of the Greek EPBD. The proposed interventions should follow the established methodological and legislative framework for calculating the energy performance for buildings and building elements and be complied with the established minimum requirements excluding cost-optimality. Implementation of the Technical Guidelines will be according and in regard to established Greek regulations and building codes and consists of four distinct stages: a) building inspection and evaluation stage (recording and assessment of a building’s architectural value and structural condition), b) concept-design stage (schedule of proposed interventions), c) approval of evaluation and design proposal including in-situ audit-procedures by authorities, and d) final design and issuance of building permit stage, followed by site inspection and supervision of the implementation works.

5. REFERENCES