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Energy savings potential in urban rehabilitation: A spatial-based methodology applied to historic centres

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ABSTRACT

Historic centres are special parts of the urban fabric that must be kept alive, to avoid depopulation and gentrification. The energy renovation of its buildings is key to achieve a balance between the conservation of built heritage and the sustainability required to meet the needs of citizens, in terms of thermal comfort and energy efficiency. We argue that adopting a holistic approach at a neighbourhood scale, instead of the traditional individual building scale, will boost the large-scale energy renovation, due to economies of scale on energy savings and investment cost. Within our approach it was designed and implemented a geospatial-based index – *Urban Energy Renovation (UER)* – integrating socio-economic variables of households, buildingsí characteristics and energy savings potential, with the purpose of benchmarking the capacity and opportunity for energy renovation in historic centres. The UER index was applied to ten historic centres in Portugal to compare energy savings potential, localize priority areas of intervention and identify contiguous areas with similar potential. We concluded that this spatial-based methodology contributes to boost large-scale energy buildings renovation in historic centres, which is key to attract new dwellers.

Contents

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Nomenclature

BGRI	Base of Referenced Information
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificates
GHG	Green House Gas
Ntc	The global nominal energy needs of primary energy consumption for heating, cooling and sanitary hot water
Nt	The legal limit of each energy efficiency class of global nominal energy needs of primary energy consumption for heating, cooling and sanitary hot water.
SP	Global average energy savings potential
SSL	Subsection
UER index	Urban Energy Renovation Index
URA	Urban Rehabilitation Area

1. Introduction

1.1. Energy efficiency potential from existent buildings' renovation

Cities are key players regarding energy and climate change issues. United Nations foresees, by 2050, more than half of the world population will live in cities and the total urban built area will triple in size [1]. The efforts to reduce energy consumption and GHG emissions on the built environment are crucial to achieve the Paris agreement (COP21) of holding the increase of global average temperature well below 2 °C above pre-industrial levels [2]. In Europe, the majority of population already lives in cities (73%) and the high urban density is characterized by a high urban concentration of energy consumption. The energy consumption of European urban areas is expected to increase at an average rate of 0,5% per year until 2030, which will result in an urban concentration of 75% of total energy consumption [3]. In Europe, the built environment is currently responsible for 40% of total energy use and 36% of CO_2 emissions [4]. However, this sector has a large potential to reduce CO_2 emissions up to 19% by 2020, below 2005 levels, and 29% by 2030 [5]. The residential sector is the biggest buildingís segment accounting for 75% of total European building stock floor space. The context of the EPBD recast underlines the need to reduce energy consumption on buildings and its climate impact and reinforces the energy certification of buildings including recommendations for retrofitting [6].

The energy performance of buildings varies according to several factors such as the building envelope, the installed heating systems, and the behavioural characteristics of occupants. The analyses of heating consumption levels by building stock age lead to the conclusion that the older the building stock, the larger the energy efficiency potential, which is generally evident for European buildings constructed prior to 1960–1970 [7]. Buildings prior to 1960 frequently lack insulation in their envelopes and consequently have higher U-values, which is a consequence of limited energy regulations in building codes at that time. The total share of old buildings with these characteristics in the European countries varies regionally between 35% and 42% [7], which explains why the building sector is a key energy consumer in Europe and the significant weight of households (69% in 2009) in final energy use in buildings.

The energy efficiency potential estimated for the existing buildings stock in residential sector for EU27 by 2030, ranges from 12Mtoe to 66Mtoe [8], taking several scenarios with different intensities of policy efforts to overcome barriers, different discount rates for investments and different rates of refurbishment. For all the scenarios, up to 2030, the energy efficiency potential from the refurbishment of existing stock makes up more than 70% of total energy savings potential of building stock (Fig. 1).

In this context, several initiatives worth to be mentioned as examples of best practices such as the case of One City Built to Last—the plan of New York city to transform their buildings for a low Carbon Future. This plan includes a comprehensive pack of guidelines to reduce GHG emissions and improve energy efficiency envisage that by 2050 most of the buildings will be high performance structures powered by low-carbon energy sources [10]. The deep retrofit of existing buildings is crucial to achieve these goals and the city is already paving the way and leading by example with deep interventions in public buildings. In addition, the plan also includes several initiatives to create a market for energy efficiency and energy renewables, that will support private owners and the massive renovation of their buildings. In the European context, we highlight the Europhit project [11] for its technical and scientific contribution regarding the design of new certification schemes for retrofits and new financing models and market incentive programmes under the passive house principles. Other European projects are focused in the energy efficient retrofitting of residential buildings using new technologies and solutions like HERB [12] and EASEE [13] projects or in the development of energy efficient districts and platforms for decision support as the cases of the European projects BESOS [14] and URB-Grade [15].

1.2. Energy savings and conservation approaches for historic centres

The historic centres are a special urban fabric within the cities with unique, historic, social and cultural identity that needs to be preserved. Historic centres are also urban areas often requiring revitalization through special interventions to revert the process of urban depopulation. In order to transform these areas to be more attractive to a larger portion of the population, they should be a sustainable and affordable alternative to peri-urban residential areas [16]. The historic centres have been considered safeguarding heritage since the mid-seventies, as expressed in the Nairobi recommendation (UNESCO, 1976) and in the *International charter for safeguarding of historic cities* (1976) later ratified [17].

There has been a significant evolution of the concepts and methodologies used in the rehabilitation and revitalization of historic towns and urban areas. *The Valletta Principles for the Safeguarding and Management of Historic Cities, Towns and Urban Areas* is a redefinition of the Washington charter that was adopted in 2011 by ICOMOS. The major redefinition of concepts includes a greater awareness of historic heritage at a regional scale, the role of the public space, the intangible values of identity, the traditional land use, social integration and environmental aspects [18]. In this sense, the heritage is considered a fundamental resource in the urban systems where the interventions of rehabilitation should include the tangible and intangible elements as well as the quality of life of their inhabitants. Therefore, the improvement of energy savings in buildings located within historic centres is fundamental to assure the comfort and well-being of their inhabitants.

It is recognized that the methodologies based on individual building are not sufficient to overmatch the energy efficiency barriers because they don't consider the whole urban energy system and the synergies created at a community level [19–21]. The energy savings approach at a neighbourhood scale is based in the energy renovation of clusters of buildings instead of a single building. This approach is being tested with several pilot projects in European historic centres, like in Montieri (Italy) and Ajaccio (France) [22], with the purpose to increase synergies within the commu-