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Estimation of building energy performance for local energy policy at urban scale

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Abstract

Cities play a key role in sustainability policies aimed at reducing environmental impacts and increasing energy efficiency in the building sector. At urban level, the analysis models are split in bottom-up and top-down types as a function of the methodological approach of input data processing, aggregated in the first case and disaggregated in the second one. The present paper describes the methodological approach adopted for the implementation of a bottom-up model able to estimate the energy performance of buildings and to define an energy diagnosis process at urban scale. Starting from the information provided by tools available at the Public Authorities and at the most relevant statistical studies on the national energy market, the model provides an estimation of the energy consumption and performance of buildings. The model is applied to a real district of Bologna and the derived spatial database allows the energy performances of buildings to be mapped.

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Keywords: Energy diagnosis; consumption; GIS; energy policy

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1. Introduction

The widespread knowledge of the building stock characteristics is crucial for the development of effective energy policies aimed at reducing energy consumption and greenhouse gas emissions. This led over the years to the development of a branch of research with the purpose to identify methods and tools able to characterize the urban fabric from the energy point of view, moving from the assessment of the individual building [1] to the district and the city as a whole [2]. This change of vision permits to plan targeted operations and to direct the resources to the most significant interventions.

Assessment models of the urban fabric performance are divided into two main approaches depending on the input aggregation level: top-down and bottom-up models [3]. Top-down models are based on aggregated input at different scale levels according to the objective; this approach describes the energy behavior of the area object of the study, providing global and wide-scale energy refurbishment solutions (e.g., regional [4] and national scale [5]). Bottom-up models instead are based on the analysis of disaggregated data, at the individual building or group of buildings level, extracted to represent the energy behavior of the built environment under investigation. This approach provides for the use of statistical models and building physics-based models [6]. The described models are not alternative; in fact several studies have combined the peculiarities of both methods in order to develop integrated approaches able to describe punctually the energy behavior of the urban area [7]. In this wide scenario, bottom-up models have met a huge success, thanks to the numerous initiatives at national [6] and international level [8, 9], implemented over the years with the aim of defining methodologies for the comparison of buildings' energy behavior. The use of reference buildings in particular, as defined by the European Directive [10], has provided an important stimulus in the application of these tools for mapping the energy consumption and performance of buildings at urban scale.

Starting from the analysis of the urban fabric of Milan, [11] defines 56 combination of archetypes by combining 4 base reference buildings, characterized by different surface to volume ratios (S/V), number of floor and size, with seven ages and two building use. The procedure allows the author to map the energy consumption and the potential refurbishment of the urban fabric, subdivided according to the census areas, by comparing the real characteristics of the building stock with the defined archetypes. [12] applies two different bottom-up models to analyze the energy consumption of the residential buildings at urban scale of the city of Turin: the first one based on the definition of specific reference building as a function of the S/V and the construction periods, the second one based on a linear regression of real energy consumption of sample buildings. The same authors developed a top-down model for the assessment of the non-residential buildings, at census scale. In [13] the authors analysis the potential for renovation of the overall building stock of the city of Kočevje by defining the initial state of buildings before renovation (concerning both thermal envelope components and heating systems). The researches described below use GIS tools to represent the current state of urban fabric [14] and the potential of renovation. Some authors have passed the boundary of energy consumption incorporating other kind of evaluation such as the thermal comfort [15], the environmental impact related to the life cycle [16], material distribution [17], etc.

The paper presents the first step of a wider methodology based on a multilevel energy diagnosis that provides the use of different sources for the analysis of buildings energy behavior at urban scale, from standard to real information. In particular, the methodology described below is based on the available open-source information about the building stock aimed at mapping the current energy performance of the building of a city and at identifying the potential of renovation. The methodology provides the analysis of both residential and non-residential buildings. Using a GIS tool specific maps are produced. The methodology is applied to a neighborhood of the city of Bologna. The system allows a diffuse energy diagnosis of the building stock and it can support the public administration to develop targeted energy policies.

2. Methodology

The bottom-up methodology proposed for mapping the energy consumption of buildings is based on the analysis of the available information provided by open-source database needed to characterize the building stock from a geometrical, morphological and energetic point of view. Through the use of this information it is possible to define a reference buildings' matrix specific for the considered area that constitutes the calculation basis of the system.