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Application of a mapping tool to plan energy saving at a neighborhood scale

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Abstract

This study proposes the application of a model for the evaluation of the overall energy demand of existing urban neighborhoods, which can be useful when planning energy enhancement strategies at urban scale. The application of this model can be interconnected with the use of a GIS software tool, thus providing the opportunity to perform the energy mapping of city neighborhoods.
In the proposed model, the overall energy demand of existing urban neighborhoods is evaluated by considering the three most energy intensive sectors: buildings, transport and urban lighting. However, in this paper the application of the model is only focused on the assessment of the energy demand in the building sector.
The proposed methodology is applied to a neighborhood of the municipality of Catania in Southern Italy. The preliminary results are reported in this study: first, the existing energy consumption for space heating and electric appliances is assessed, then the effectiveness of a series of energy-saving strategies is considered, thus providing a tool to implement effective energy planning policies at urban scale.

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Keywords: district, energy planning, energy savings, refurbishment

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1. Introduction

In the last decades the contrast to climate changes, mostly related to human activity, has clearly emerged as a basic priority [1]. The mapping of world's primary energy demand and of emissions has pointed out that urban areas are responsible of 75% of the overall consumption and of 60% of GHG. But, while being part of the problem, cities are also part of the solution [2], as they have the potential to reduce CO2 emissions significantly [3].

The recognition of cities as complex systems behaving more like "organisms" than "machines" is the basis for a change of paradigm in the analysis and the potential optimisation of energy flows [4]. As opposite to previous approaches, according to this paradigm urban areas are regarded as being organised in a bottom up structure, in which energy flows are determined by a limited number of sub-systems, such as buildings, transport, human activities and green areas [5-6], and by their interaction. In fact, the assessment of energy consumption is mostly developed with sectorial approaches, frequently focusing on the building sector [6-11]. On the other hand, interactions are not fully taken into account, though, occurring at different scales, they represent a key element of the system complexity. Therefore, limitations arise to the traditional approach, that sees the substantial independence of urban planning and energy policies, which implies the need for an integration of energy action planning and urban planning.

Within this perspective, Jones et al. [12] developed the Energy and Environment Prediction Model (EEPM) as an analytical tool to assess energy use and carbon emissions for different sectors in urban areas described by separate sub-models. More recently, Reiter and Marique [13] proposed an integrated method to evaluate energy consumption in suburban neighbourhoods of Walloon region. The model quantifies energy consumption associated to buildings, transport and public lighting, integrating the outcomes to determine the overall consumption of a neighbourhood.

Fichera et al. proposed a strategy to assess the overall energy demand of existing urban neighbourhoods, including the contribution of indoor space heating, household electricity consumption, outdoor lighting and transport [14]. The proposed methodology constitutes an analytical tool that aims at providing an estimation of the global energy demand of existing urban neighbourhoods, even when there is lack of reliable data. The applicability to urban neighbourhoods makes the model suitable for spatial planning applications. In fact, district level is widely considered the right scale for the implementation of energy and planning actions in sustainable town planning [5].

Moreover, the model may be further applied to configure urban energy scenarios through GIS modelling; in fact, combining urban energy mapping and scenario analysis allows to determine integrated planning – energy strategies and to support sustainable political choices on existent urban areas.

Starting from the more general methodology developed in [14], this paper only deals with indoor space heating, with the aim of showing how the proposed mapping tool can be used to study the effectiveness of energy saving strategies in this sector at a neighbourhood scale. In particular, the sub-model implements a mixed method, integrating aggregated statistical and individual building approaches as suggested by Dall'O et al. [7], that yields, through the linear regression of the data, the correlation between EP_H and S/V ratio for different construction periods of the examined building stock. In accordance to Ascione et al. [6], the implemented approach determines the energy performance of buildings by simplifying the national standard procedure and, on this basis, proceeds to the energy mapping of the urban area.

2. Methodology

The model for the calculation of the energy needs for space heating is based on the procedure outlined in the Italian standards UNI-TS 11300 [15, 16]. In particular, the standards contemplate a simplified procedure (*asset rating*), applicable to existing buildings with the purpose to determine a conventional performance level. According to the simplified procedure, the thermal energy needs for space heating can be calculated as in Eq. (1):

$$Q_{H,nd} = \underbrace{\left(Q_{H,tr} + Q_{H,ve}\right)}_{\text{Heat losses}} - \eta_{H,gn} \cdot \underbrace{\left(Q_{sol,w} + Q_{int}\right)}_{\text{Gains}} \quad (1)$$