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A mixed methodology for defining a new spatial decision analysis towards low carbon cities

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Abstract

Cities play a leading role in economic development, security, sustainability, and climate change. The fact that the built environment energy consumption contributes to a huge amount of CO2 emissions has a significant impact on the public agenda. Consequently, the emergence of the low carbon city concept has enhanced the necessity for a both quantitative and qualitative evaluation of related energy strategies and policies. Support decision maker's tools can play an essential role for sustainable and effective land use governance, in particular, geo-referencing territorial data. This paper proposes a mixed approach method, integrating GIS Urban Energy Mapping, Stakeholders Analysis, and Multi-Criteria Decision Analysis whit the aim at defining urban energy saving scenarios in two sides which includes (a) the development of an energy consumption model of the building stock that is able to explore a number of possible futures scenarios based on GIS and give a representative picture of the actual energy consumption state and performance of urban systems (b) and the pre-selection of evaluation criteria based on environmental, economic, and social sustainability pillars. The expected result is the development of spatial decision support tool able to support urban planners, policy makers and built environment stakeholders in their efforts to plan, design and manage low carbon cities in their future strategic decisions by visualizing scenarios analysis. This paper is part of an ongoing Smart City research, a national cluster project, called Zero Energy Buildings in Smart Urban Districts (EEB).

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Keywords: "Multicriteria Analysis; Urban Energy Consumption; GIS; Sustianble Development Indicators

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1. Introduction

Cities play a prominent role in sustainable development for different causes, particularly, more than half of the word population settle in urban areas and expecting to have this number enhanced to 64-69%, or 5.6-7.1 billion by 2050 [1]. Moreover, urban sprawl and the way that cities are growing and operating have an immense detrimental impact on environment and its energy demand [2]. Interestingly, urban areas account for about two-thirds of the world's energy [3]. Almost always, the most considerable source of greenhouse gas (GHG) emissions comes from either energy use in transportation or building sector [1].

Although built environment sector is very challenging (i.e. multiple stakeholders with varied and conflicting preferences and interests), provides cities with low-cost and short-term opportunities for emissions reductions first and foremost through the energy performance improvement. The European Commission emphasizes that emissions in this area could be reduced by about 90% by 2050, which is greater than average share value over the long-term [4]. This fact highlights the significance of attaining the objective of the recast Directive on energy performance of buildings that new buildings built from 2021 onwards will have to be nearly zero-energy buildings [5].

The rise of climate change, since the late 80's, on the public agenda and more recently of the concept of "Low carbon city" have emphasized the need for quantitative assessment of mitigation and adaptation strategies [6,1]. Energy policy in EU is based on three balancing components: competitiveness, sustainable development, and security of supply fundamental strategies [7,8].

Needless to say, there is a wide consensus on the concept of sustainable development that refers to three intersecting pillars: environmental, social and economic [9]. Furthermore, the rising attention to the institutional dimension, highlights the importance of policies, regulation, governing structures, urban protocols and sustainability principles for supporting cities in the transition towards sustainable development [10,11,12].

One of the most effective sustainable assessment tools in the development of models process, and support any decision that might be made at the present or in the future is Multi-Criteria analysis (MCA) [13]. Sustainable criteria lead to simplify and aggregate technical and social science information available to policy makers and stakeholders, and consequently, they help to set targets [14]. In the building sector, particularly, energy consumption is influenced by the spatial organization. Accordingly, many different approaches and tools are developed for the spatial representation of energy demand, supply and CO2 emissions such as a Geographical Information Systems (GIS) [15, 16,17,18,19,20].

This paper proposes a GIS-based simulation model for testing how different scenarios and building typologies affect energy performance and carbon emissions. In particular, a "mixed approach" methodology is suggested, which aims at defining urban energy saving scenarios, including (a) the development of an energy consumption model of the building stock that is able to explore a number of possible futures scenarios based on GIS and give a representative picture of the actual energy consumption state and performance of urban systems (b) and the pre-selection of evaluation criteria based on environmental, economic, and social sustainability pillars. The expected result is the development of spatial decision support tool ale to support urban planners, policy makers and built environment stakeholders in their efforts to plan, design and manage low carbon cities in their future strategic decisions by visualizing scenarios analysis.

The rest of the paper is organized as follows: Section 2 discusses the mixed methodology and its steps, including the building stock characterization to create an urban energy consumption mapping (current state energy map), which is later be used as a basis of saving scenarios analysis. Section 3 presents the pre -selection of relevant criteria supporting transition towards low carbon cities with aim at integrating them to urban energy map. Finally, conclusions are summarized in Section 4.

2. A Mixed Methodology for the Evaluation of Energy Saving Urban Scenarios

This section aims to offer a methodological framework able to support decision making in developing and evaluating Energy Saving Urban Scenarios. In particular, an iterative mixed methodology is proposed which joints GIS Urban Energy Consumption Mapping (UECM), with Multi-Criteria Decision Analyses (MCDA) (operations research approach) and Stakeholders Mapping (SM) (social research approach) is discussed. The meaning of integrating different tools and methods in this framework is due to their complementarity in fulfilling different tasks