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A study on the use of outdoor microclimate map to address design solutions for urban regeneration

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Abstract

Climate change and the deriving impacts on the built environment certainly represent one of the most challenging issue for several key players involved in shaping the cities of tomorrow. This is not simply a matter of adapting buildings to new requirements, but rather to rethink the way the urban fabric reacts to new and sometimes unpredictable phenomena. The process is related to increasingly evident extreme conditions in the summer time, that strongly improve the energy demand for cooling with negative impacts on the energy balance as well as on thermal comfort conditions of the end users and of urban population with severe implication on health and wellbeing. Outdoor comfort depends on a number of inter-related factors: the characteristics of the built environment, the relationship between materials and energy use, global climate change and local micro-climate: Temperature, Solar Radiation, Wind distribution, Wind Speed, Absolute and Relative Humidity. The objective of this specific study is to test the microclimate modeling of a city portion in a demo-case – a plot of building blocks with inner courtyards – as a tool for supporting the regeneration phase addressing technological choices and design solutions to improve outdoor comfort conditions. The outcomes of the performed envi-MET simulations, comparing the situation before and after intervention, are consequently discussed. In the specific case, the developed project involving the courtyard has led the Thermal Comfort perception, evaluated in terms of PMV, to shift from "very hot" (+3.50, +4.00 red zone) and "very very hot" (above + 4.50 violet zone) to "Warm" (+1.50, +2.00) at urban plot scale.

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Keywords: Outdoor thermal comfort; envi-MET; district regeneration; outdoor microclimate map [OMM]; climate responsive solutions; mitigation

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1. Introduction and context

One of the most challenging issue in addressing the future form of the cities in the next future is certainly connected with the answers to climate change and the deriving impacts on the built environment [1]. New design paradigms are expected not simply to respond to new requirements for adapting buildings to emerging needs, but rather to enable a reaction to new and sometimes unpredictable phenomena [2]. On the one side, this is related to increasingly evident extreme conditions in the summer time (and altered winter/summer cycles especially for what concerns the temperature trends and the rainfalls) that strongly improve the energy demand for cooling with negative impacts on the energy balance [3]. On the other one, this affects the thermal comfort conditions of the end users and of urban population with severe implication on health and wellbeing. The most evident phenomena at city level are the so called heat-waves and the Urban Heat Island [UHI] effect that may lead to critical consequences such as heat strokes and generally to a sense of outdoor discomfort [4, 5]. According to the Adaptation Plan adopted by the City of Bologna, this topic was included in a study, developed by the Technology Research Unit of the Department of Architecture at University of Bologna, concerning the regeneration of Bolognina district with the aim to define effective pathways for integrating energy efficiency measures, climate condition monitoring and renewable energy exploitation into a smart city perspective [6].

The importance of considering the climate and micro-climate condition of the space in-between the buildings, defined as a very specific environment shaped into courtyards, passages and outdoor spaces enclosed by aggregated volumes, emerged from the beginning as a strategic element in the general framework of the research.

The main driver of the study was to provide cost-effective solution to reduce energy demand at building scale while increasing quality and comfort condition [7, 8, 9] as well as to deliver a comprehensive strategy to support the integration of the district in smart-city related infrastructures. During the work, the role of the intermediate scale at district level clearly emerged both with reference to the achievement of a systemic effect for energy management and to the impacts in terms of mitigation potential. The district is indeed organized in a very regular grid of rectangular plots where building blocks are arranged around one or more inner courtyards or green areas. The analysis of the microclimate condition of these spaces assumed a relevant importance in the approach to the regeneration process as a whole and particularly in the understanding of outdoor comfort implication. Despite this represents just a part of the overall context of the research, outdoor comfort captured the team attention and a dedicated study was developed on a portion of the district in order to evaluate the impacts and the potentialities before applying the process at a larger scale.

Outdoor Comfort is a specific field of study and its linkage with UHI phenomenon is quite clear: UHI recurrence is directly related to the outdoor temperature increase [10, 11]. As a reaction, people tend to stay inside the buildings with a consequent increase of energy demand due to HVAC use in cooling mode.

However, the performed review of the scientific literature evidenced that outdoor comfort and related phenomena are mostly studied at two different level:

- the climatic one, well represented by some works of Matsarakis and Santamouris [4, 5, 12], that analyses UHI at large scale focusing on the relation between climate conditions and the deriving effects on the city and particularly on the dense city centers and historic/touristic sites;
- the material one, that focuses on the characteristics of the elements at building scale to reduce the risk of overheating, working on specific parameters such as albedo and reflectance which were widely investigated in studies of Doya, Hernández-Pérez and Zinzi [13, 14, 15] among the others.

A minor attention is usually given to this issue at district meso-scale where, working on surfaces bordering a limited outdoor space, is possible to influence its micro-climate and the perceived comfort.

The paper reports the specific study developed on a portion of the main research project case-study describing the main goals, the assumed constraints, the key parameters investigated, the adopted methodology, the main outcomes and the potential impacts within the general scope of the main project.