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Comparing real and predicted window use in offices. A POE-based assessment

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Abstract

Accurate predictions of human-building interactions are essential to decrease energy waste and improve indoor comfort. Although users' dynamic behaviour has been recognised, most of simulation programs still work using deterministic rules. This paper investigates the effectiveness of both deterministic and stochastic models in reproducing window openings, using a Post-Occupancy evaluation (POE). A summer monitoring campaign in offices settled in Mediterranean climate was performed to acquire experimental data. Results highlight that deterministic approaches poorly reflect real behaviours. Probabilistic models seem to represent effective users' actions. Findings demonstrate the urgent need of behavioural approaches in simulations.

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Keywords: human behaviour; widows use; stocastic model; Post-Occupancy evaluation; building energy performance

1. Introduction

Decreasing building energy consumptions is one of the most relevant goals for architects, engineers and building construction industries [1]. In recent years, the overall building efficiency was improved thanking the development of innovative building materials, technological systems, and devices for smart buildings. These solutions have been mainly focused on building energy performance as a function of physical features of built environment, used

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materials and components. At the same time, they are generally based on a schematic approach to the relation between these elements and management strategies, indoor conditions, occupants' behaviours, individuals' comfort perception, differences between people's features, dynamic interactions evolution during the time [2,3]. A similar deterministic and "a priori" design method is also adopted by other architectural issues (e.g.: safety, building use and space configuration) and it has been also codified by design and planning guidelines, regulations, tools [4].

Although users-environment interactions from current schematic guidelines are based on real-World experiments concerning occupants' behaviours, many recent studies highlighted the lack of appropriate evaluation of the "human factor" incidence on building energy consumptions. These works often retrieved a relevant gap while comparing real and predicted performances [5,6], since users do not deterministically act on building devices. These forecast models should prefer the adoption of a probabilistic point of view in representing the individuals' action mechanisms. This would be possible by using a "behavioural design" (BD) approach [7,8], which has as keystones for the models' development the real human-energy behaviours and the users-environment interactions.

This study is aimed at providing first steps in the use of a BD approach by focusing on the analysis of window use in Mediterranean offices and adopting a POE-based assessment. The final purpose of such activities is to evidence differences between current Building Energy Performance Simulation programs (BEPS) rules (forecasted windows use) and effective human behaviours (real windows use) and to propose an experimental BD-based probabilistic model. Assessment results would outline which forecasting approach could be the best for a similar scenario. Once opening trends are identified, the study intends to investigate reasons for windows' interaction through subjective analyses (i.e.: individual's questionnaires) and to evaluate whether subjective and objective approaches match. Results offer new insights on window use in Mediterranean offices, giving inputs for model implementation.

2. Including occupants' behaviors in simulation

Occupants' activities in buildings and the complex users-environment relation seem not to be correctly taken into account by current BEPS. In fact, the majority of existing programs uses fixed schedules to predict occupancy patterns and users' interaction with building devices (e.g. lights, windows) [9]. They simulate occupants' actions using deterministic rules that barely represent real behaviours, such as the ones connected to simple environmental conditions-dependence thresholds [10]. On the contrary, as for other building design topics (e.g.: safety), these models should be directed towards a BD-approach [7,8], which is based on:

1) *analyses of the individual's behaviours and group effects* (interaction with the environment, and their characteristic parameters, as well as among the occupants) while people are living in real-World built environments, by means of experimental analysis, such as the ones based on Post-Occupancy Evaluation (POE) techniques [11];
2) *definition of models* for representing their interactions in the architectural space;
3) *development of simulation software and validation* with comparisons performed on real-World data;
4) *analysis of the impact of occupants' actions against the building performance levels* through simulations, and then *propose interventions* (e.g.: development of new building components, including smart ones, and technological systems) according to these behavioural simulation results (in case of energy issues, with the purpose to increase occupants' comfort levels and reduce energy consumptions).

Then, tests (i.e.: POE-based) could evaluate the forecasted impact of proposed solutions.

This approach has been tested on window use, since it is one of the most adopted actions and it has a very high impact in terms of energy consumptions, especially in naturally ventilated buildings [12].As for many other behavioural issues, even if many researchers underlined that a probabilistic approach better predicts this interaction [13], the majority of BEPS still use standard deterministic ones. These rules for windows opening are based on:

- fixed thresholds for indoor temperature (higher than an imposed limit) [10];
- comparisons between indoor and outdoor conditions (indoor temperature higher than the outdoor one);
- adaptive models of international standard, such as EN 15251 [14] and ASHRAE55 [15], that consider the relationship between operative and comfort temperature.

These rules seem not to be able to represent effective human behaviours since they excessively simplify the occupants' interactions with building devices. In fact, previous researchers suggest how the windows