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EDITORIAL
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Editorial: Modeling Occupant Behavior and Quantifying Its Impact on Building Energy Use

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Editorial on the Research Topic

Modeling Occupant Behavior and Quantifying Its Impact on Building Energy Use

The Research Topic aimed to nourish a deeper understanding and dissemination concerning the modeling of occupants' behavior (OB) in buildings to obtain a more realistic prediction of energy uses. In this area, effective examples of development and integration of OB models with tools and design processes were collected.

With reference to residential buildings, the study conducted in Veillette et al. was inspired by the assumption that, in this sector, energy consumption and thermal comfort are highly influenced by occupant behavior, which can exhibit significant temporal and spatial variability.

The objective of this study was to enhance the understanding of how window-to-wall ratio (WWR) of a residential unit affects heating demand and thermal comfort considering occupant behavior (OB) diversity. Such a diversity was explicated by a stochastic occupant behavior model able to generate a high number of user profiles. The OB model was integrated in the energy simulation of the dwelling, obtaining probability distributions of energy consumption and comfort for different WWR. The study shows that the shape of the probability distributions is affected by WWR and dwelling orientation, and that the influence of different OB aspects of performance also varies with WWR value. Overall, these findings could help designers to better assess the impact of WWR for a large spectrum of occupant behavior profiles.

The importance of reviewing the OB factor in the residential sector was also highlighted in Tavakoli et al.

In this study, occupants' energy behaviors in a residential complex in Isfahan, Iran, are investigated by means of a questionnaire, field measurements, and building performance simulation. The investigation aimed to answer the question, "To what extent can OBs patterns and apartment improvement strategies affect energy consumption?". As a consequence, the main objective was to identify the impact of apartment improvement and OBs, including windows opening, curtain controlling, and turning on heating equipment on energy consumption. Structural equation modeling (SEM) was applied and the study showed that the most influential behavioral factor was related to the improvement sector with a 41.7% share of electricity consumption. Regarding gas consumption, the most and the least determining behavior factor were attributed to apartment improvement and curtain controlling behavior with an effective rate of 64.5 and 5%, respectively.

Moreover, a better identification and quantitative understanding of factors that influence OB and thermal state can support effective energy-efficient design.

In Rentala et al. this issue was considered using an innovative approach that applies immersive virtual environments (IVEs) capable to capture the underlying causal interactions between the

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influencing factors. A set of experiments involving 72 human subjects was performed through the use of a head-mounted device in a climate chamber. The subjects were exposed to three different step temperatures under an IVE and a baseline *in-situ* condition. Participants' individual factors, behavioral factors, skin temperatures, virtual experience factors, thermal states, and energy behavioral intentions were collected. Structural causal models were learnt from data using the elicitation method in conjunction with the PC-Stable algorithm. The findings show that the causal inference framework is a potentially effective method for identifying causing factors of thermal states and energy behavioral intentions as well as quantifying their causal effects. In addition, the study shows that in IVE experiments, the participants' virtual experience factors such as their immersion, presence, and cybersickness were not the causing factors of thermal states and energy behavioral intentions.

An enrichment of knowledge was offered by the pragmatic theory of OB in indoor environmental control presented in Mahdavi et al. The development of this theory and the associated schema was motivated by recent trends toward more detailed, dynamic, and realistic representations of occupants in the computational building modeling and, in general, in building performance simulation. Efficient generation, refinement, and sharing of occupant models can benefit from a shared ontology. Systematic and robust ontologies benefit, in turn, from the prior availability of a versatile behavioral theory. Such a theory can specifically capture those aspects of human perception and behavior that are relevant to building performance assessment and prediction. An examination of the proposed theory, conducted *via* a thought experiment, suggested that it can offer consistent and plausible narratives with regard to the background and reasons for occupants' interactions with buildings' control devices. The proposed theoretical framework has been thus shown to cover the essential ingredients of a general ontology of occupants' control-oriented behavior in buildings. Moreover, the proposed theory and the derivative ontology act as the reference framework for the agent-based representation and modeling of occupant behavior and its impact on buildings' energy performance. Such an ontology is currently under development.

A general consensus was found in the papers' collection: tools for building design and operation still entail detailed representations of buildings' geometry, construction, and systems, but more efforts should be aimed at enhancing the relatively less developed models of users and the integration of OB diversity. This target can be reached by intensifying the investigation in field, that offers the data base for OB models development. On the other hand, more theory is needed to inform the efforts toward the construction of occupant models in computational applications and to guide the formulation of occupant-related ontologies and their instantiation in energy tools. Moreover, encouraging occupants through education and policies could play another essential role in changing OBs patterns to optimize energy consumption. Further research should assess the effect of OBs on energy consumption in different climates, cultures, large scale samples, and building types. Using an extensive set of influencing factors such as environmental, socio-demographic, physiological, and as well as time-dependent and physiological factors to build OB models is another challenge.

AUTHOR CONTRIBUTIONS

The author confirms being the sole contributor of this work and has approved it for publication.

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