Doctoral Dissertation
Doctoral Program in Energetics (31st Cycle)

Title: Impact of Occupant Behaviour (OB) on building energy use and thermal comfort - From stochastic modelling and occupant profiling to interdisciplinary user engagement

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ABSTRACT

Occupant behaviour (OB) has been acknowledged to be one of the key factors of uncertainty in prediction of energy consumption in buildings. Building occupants affect building energy use directly and indirectly by interacting with building energy systems such as adjusting temperature set-points, switching lights on/off, using electrical devices and opening/closing windows. Indeed, within the energy and building research community occupant-centred approaches and analysis are gaining continuously more attention and significant research effort is put on gaining a deeper knowledge on the human interaction with the building systems and envelope. These efforts are mainly focused on reducing estimation uncertainties related to the human factor in building energy analysis and design, as well as the active engagement for a more aware behaviour of the occupants in view of reaching energy efficiency goals.

The introductory chapter (Chapter 1) outlines key aspects of the state-of-art in current behavioural research and highlights **research gaps and shortcomings** in the current research body that have stirred the focus of this dissertation, such as:

(i) Lack of understanding to which extent OB can impact building energy use and thermal comfort in high performing buildings;
(ii) Gap between real and predicted building energy use due to an oversimplification (e.g. fixed schedules) of the human factor in simulation programs;
(iii) Absence of qualitative data and individual characteristics and preferences of building occupants in existing models;
(iv) Lack of reliable and affordable ways to collect large-scale occupant behaviour data;
(v) Lack of innovative solutions for motivating and assessing behavioural change towards energy efficiency goals.

Given these current limitations in existing literature, this doctoral research is aimed at addressing the following **research questions:**

(i) How significant is the impact that OB might have on building energy use and thermal comfort conditions of the occupants, especially in the context of high performing and technologically optimized buildings, in which the human factor might play an even more

significant role than in buildings whose envelope-driven loads dominate the consumption profile?

(ii) Is there an innovative approach to model the stochastic nature of the human-building interaction influenced by key environmental and time-related drivers towards bridging the gap between real and predicted building energy use?

(iii) Which role do qualitative data and individual characteristics of the occupants play (e.g. thermal comfort attitudes) and how can they be introduced in the modelling process?

(iv) Is there a reliable way for profiling OB on a large scale to provide enhanced building simulation input?

(v) How to engage and assess behavioural change to optimise building operation and well-being of the occupants?

In this context, the **methodological framework** of this dissertation (see figure below) is aimed at contributing to new knowledge in occupant behavioural research through the development and implementation of methods for

(i) estimating the **impact of OB** on building energy use and thermal comfort in low energy buildings (Chapter 2);

(ii) exploring the Bayesian Network framework for developing advanced **stochastic OB models** (Chapter 3);

(iii) introducing qualitative data and individual characteristics of the occupants in these models through tailored **OB surveys** (Chapter 4);

(iv) **profiling OB** (daily activities and occupancy) on a **large scale** based on Time Use Survey data (Chapter 5);

(v) developing and evaluating **energy engagement** campaigns in different environments to improve OB and raise user awareness (Chapter 6).