POLITECNICO DI TORINO
FIRST SCHOOL OF ARCHITECTURE
Master of Science in Architecture Construction City
Honors theses

Influence of occupants' behaviour on heating energy consumption and thermal comfort in residential buildings.
A switch from a deterministic to a probabilistic approach in energy dynamic simulation tools, for a better prediction of building energy performance
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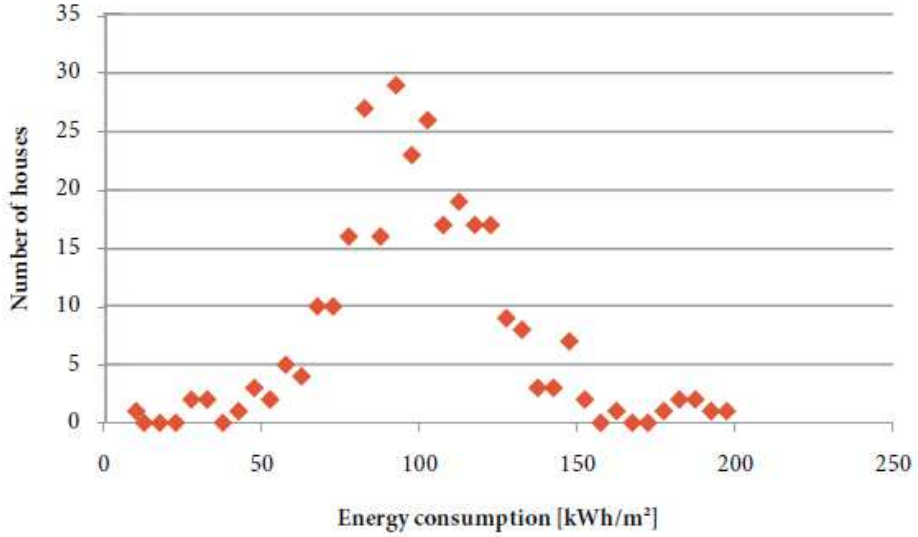
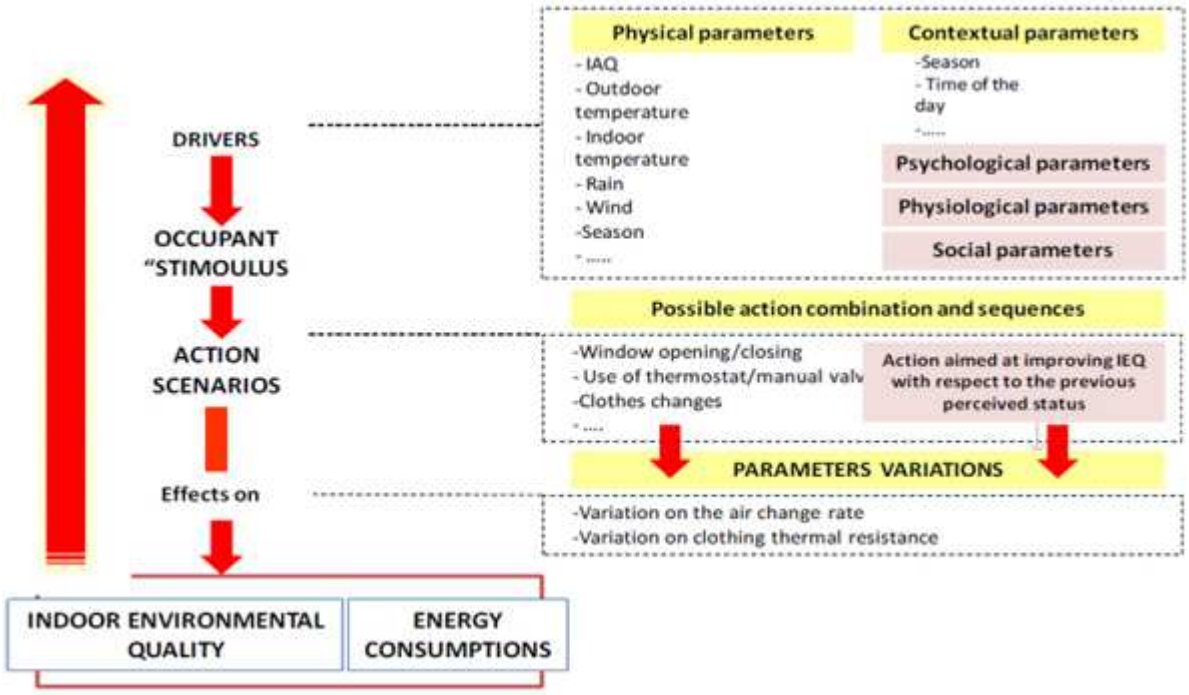
Existing dynamic energy simulation tools exceed the static size of the simplified methods through a better and more accurate prediction of energy use; however they are still unable to replicate the actual dynamics that govern real energy uses within buildings. For instance, the traditional approach to building dynamic simulation considered energy consumptions as fully deterministic, on the one hand taking in to account standardized input parameters, on the other hand using fixed schedule (lighting level, occupancy, air change rate, thermostat set-point). On the contrary, events in nature never replicate themselves as equal over time, but are distinguished for intrinsic fluctuations in performance and intensity. Moreover, in everyday practice, occupants inter-act with the building plant system and envelope in order to achieve desired indoor environmental conditions. Each of these actions generates uncontrollable variables, hence real energy consumption can vary up 3 times, as highlighted by several research presented in literature, when compared to design stage predicted energy performance.



Energy consumption variation up to 3 times between apartments of the same building [Andersen, 2008]

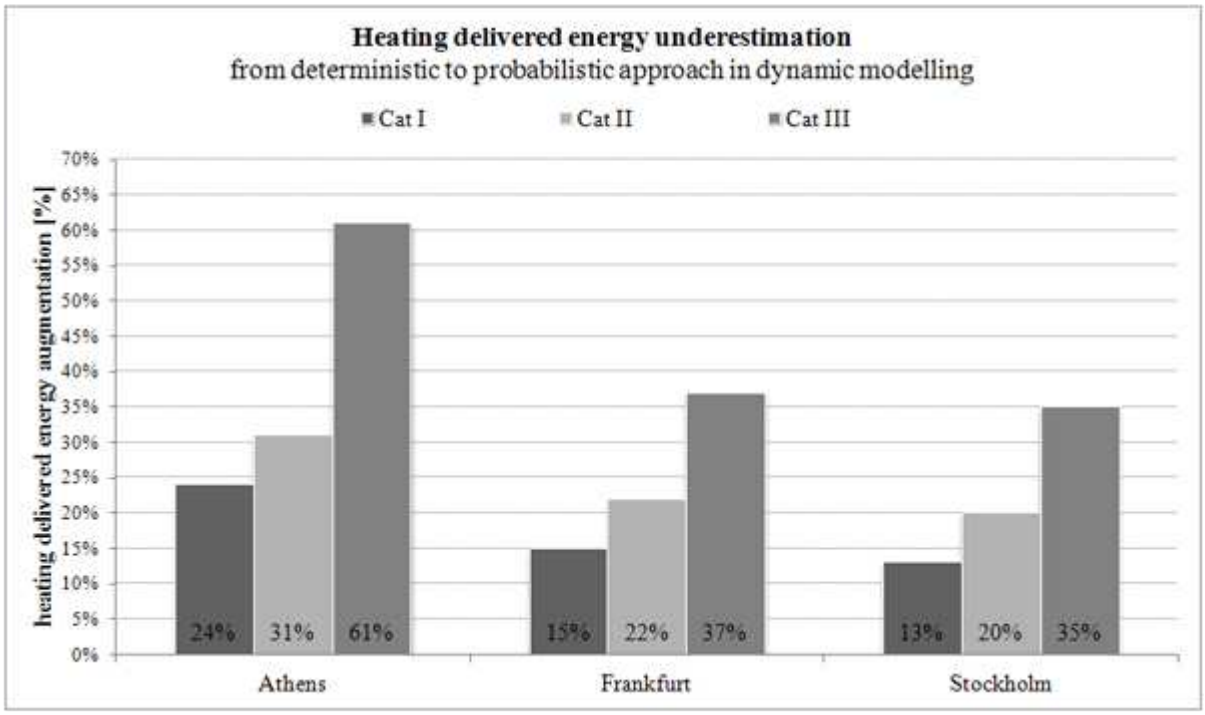
Among the main parameters influencing building energy consumption, occupant behaviour is therefore emerged as one of the main responsible in denying full effect of building energy consumption previsions.
With the purpose of a better prediction of total energy consumption in buildings, this thesis is taking into account the role of users behaviour, through the clarification of the main factors, also called "*drivers"*, which literally push - drive - occupants, to the realization of a certain action in order to improve, more or less consciously, their standard of comfort within an environment, based on precedent experiences. For instance, the main six drivers recognized by the literature as influencing energy occupant behaviour in buildings are physical parameters (indoor and outdoor temperature), psychological (preferences, attitudes), biological (age, gender) environmental (type of environment where the occupants are located) and from group interaction (income, lifestyle). It is therefore clear that behavioural actions can't be easily predictable, since internal and external parameters continuously interface between each other, driving at any time subjects to different stimuli.



From drivers to energy consumptions and indoor environmental quality [Fabi et al, 2012]

The thesis is focusing, in the framework of the international project ECBCS Annex 53 "*Total energy use in buildings - analysis and evaluation methods*" of the International Energy Agency, on the development of a new methodological approach able to understand the complex networking connection of internal and external drivers and to replicate the process leading occupants to interact with building systems and envelope. Main objective of the project is therefore to describe occupant behaviour by probabilistic models, which necessarily take into account the possibility that an action is carried out through statistical input parameters.

As a matter of fact, the new method defines behavioural models by using a logistic regression function based on a statistical analysis of a data set built on monitored occupants' real interaction within the building-plant system and envelope. For the first time in the research issue of occupant behaviour, two probabilistic variables (heating set point adjustments and windows openings) have been implemented in the same behavioural model, by using the dynamic simulation program IDA ICE.
Findings of the research demonstrate that pre-defined thermostats setting and air change rate used in widespread standards (such as deterministic categories of comfort range acceptability of European Standard 15251:2006) are far away from actual occupants preferences in buildings. For this reason, not to consider human interaction within building envelope and control systems will necessary lead designer and modellers to underestimation of heating delivered energy and therefore total energy performance in buildings.



The gap between deterministic and probabilistic energy consumption prediction

The analysis methods, developed models and results of this thesis could be taken as starting point for future projections aiming at further improvement in energy building performance prediction, not only in the residential sector but also in office buildings. On the one hand, the possibility of implementing more statistical variability of user control over indoor environmental conditions would be strongly appealed in the perspective of a switch from standard building energy performance to actual building global energy use.

On the other hand, the deployment of this research, by means a more robust definition of user behavioural profiles, will hopefully be one element towards the progress of a pre standardisation of ready-for-use predictive models in building energy simulation.

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