POLITECNICO DI TORINO
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Honors theses

Occupants' action scenarios. Influence on indoor environmental quality and energy consumptions

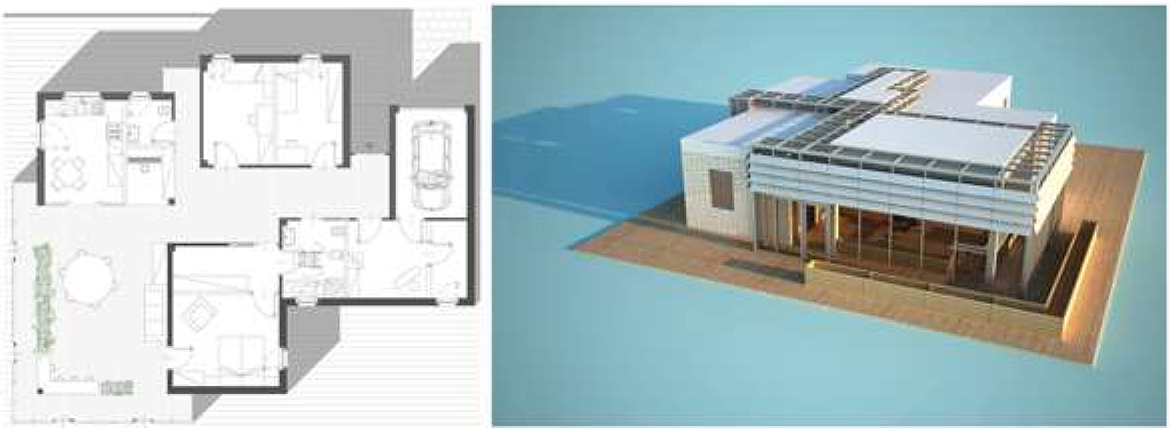
by Francesca Venezia
Tutor: Stefano Paolo Corgnati
Co-tutors: Bjarne W. Olesen, Rune Vinther Andersen

One of the aspects that highly influence environmental pollution in developed countries is the use of energy in buildings. Throughout the world the building industry and the built environment are some of the larger contributor to energy and material use. In the northern part of the European Union, 41% of the total energy consumptions comes from buildings, with 30% of which being used in residential buildings. As a consequence reductions in buildings consumed energy and related CO_2 emissions are the main goal of sustainable architecture.

Building simulations programs are becoming more and more used in the design phase of the building but most of the tools are only capable of accurate simulations of the physical properties of the buildings. In fact the ability of simulation programs to calculate real energy use is undermined by a poor representation of the stochastic variables that relate human interactions with the control of the indoor environment.

The reason of the discrepancy between simulated and real energy use in buildings lies in the fact that simulation tools are only able to describe control actions modelling deterministically and following predefined, fixed and unrealistic *schedules*. Indeed models of human behaviour are generally described by statistical algorithms while simulation tools are based on equations and mimic user behaviour in a very static way. Assumptions are generally applied to describe user presence and actions in buildings but user behaviour is much more complex. In regular energy simulations it is impossible to establish how much close the results would be to the real total energy use.

In a first phase of the research energy simulations were ran on a case study. In the simulations the deterministic approach was followed, that is the actual method used in nowadays simulations and that is based on predefined schedules.



EN15251			Results of Energy Simulations				
Comfort category	Ventilation rate (l/(s-m2))	Temperature for heating (°C)	Heating, EP (kWh/m2)	HVAC, EP (kWh/m2)	Lighting, EP (kWh/m2)	Equipments, EP (kWh/m2)	Total Energy, EP (kWh/m2)
I	0.49	21.0	22.65	22.23	27.63	11.28	83.80
II	0.42	20.0	14.75	19.05	27.63	11.28	72.72
III	0.35	18.0	5.52	15.85	27.63	11.28	60.29

Fig 1 *Deterministic approach for a case study. Results: yearly primary energy consumptions for different comfort categories according to the European Standard EN 15251*

In the recent years an attention towards probabilistic modelling of human behaviour in buildings have grew and it is now necessary to take into account occupant's interactions in order to obtain values that are closer to real energy use. In order to do this, equations describing human behaviour needs to be implemented in simulation programs and a method for a better prediction of energy demands have to be defined.

Nowadays software are not currently able to adequately evaluate scenarios explaining occupant behavior influence that in fact is the crucial node in the effort in reducing buildings energy consumptions and that have been the main goal of this thesis. The effort was to define realistic user profiles to be implement in most of the buildings simulation tools.The work described in the thesis mainly focused on the investigation on how different probabilistic users patterns (respectively active, medium and passive users) influence indoor environmental quality and energy consumptions with the aim to compare the obtained results with a regular use of the simulation program IDA ICE.

Starting from a monitoring database of 15 Danish dwellings, heating behaviour of occupants were analysed by means of logistic regression in order to infer the probability of adjusting the heating set-point of the thermostatic radiator valves. The results of the statistical analysis defined three user profiles for the simulation of occupant's interaction with heating controls to be implemented as inputs within a building simulation tool. Findings show how comfort categories have a significant impact on indoor environmental quality and highlight their influence on energy consumptions.

Fig 2 *Probabilistic approach. Results of yearly primary energy consumptions for different comfort category and for users types active, medium and passive*

In the last phase a series of simulations were run for each user behavioural model finally trying to describes energy consumptions results through a probabilistic distribution of values for each user type. Furthermore indoor environmental quality depending on user behaviour and comfort category has been calculated.

The main intent of this thesis would be to show a methodology applicable for all the aspects of user interactions with building and system such as window openings, shading devices, lighting, etc. in the aim to achieve always more realistic predictions of energy consumptions.

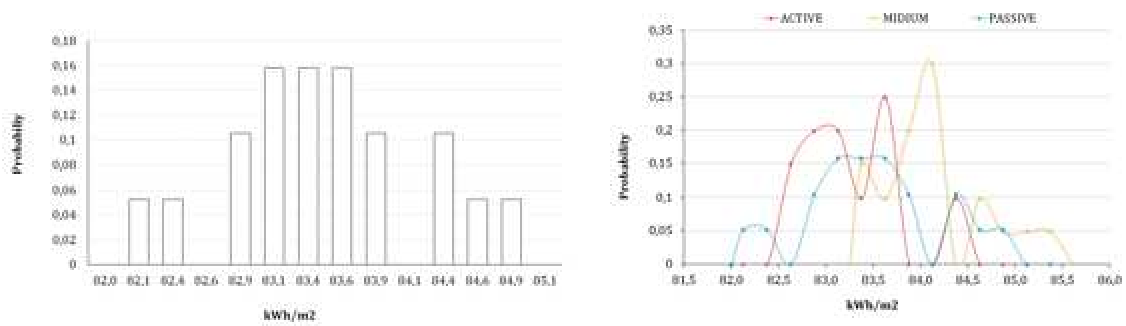


Fig 3 *Probabilistic distribution of yearly primary energy consumptions for active user type and probabilistic distributions of yearly primary energy consumptions for different user types*

For further information, e-mail:
Francesca Venezia: venezia.francesca@gmail.com