Agenzia nazionale per le nuove tecnologie, l'energia
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RICERCA SISTEMA ELETTRICO

Comportamento dell'utente: fattori influenzanti il consumo energetico e modelli descrittivi (IEA – ECBCS Annex 53)

M. Filippi, S. P. Corgnati, V. Fabi, N. Talà

DIPARTIMENTO ENERGIA

Report RdS/2010/119

STATISTICAL INVESTIGATIONS AND DATA-DRIVEN PREDICTION METHODS TO ASSESS TOTAL ENERGY USE IN BUILDINGS (IEA – ECBCS ANNEX 53)

M. Filippi, S. Paolo Corgnati, V. Fabi, N. Talà (Politecnico di Torino, Dipartimento Energia)

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Sommario

L'attività condotta dal gruppo di ricerca TEBE (www.polito.it/tebe) del Dipartimento Energia del Politecnico di Torino si è sviluppata all'interno dellelinee di approfondimento dettate dal progetto ECBCS-Annex 53 "Total Energy Use in Buildings" della International Energy Agency, iniziato con le riunioni preliminari nel 2009 e termine nel 2012. Il gruppo TEBE ha partecipato in modo propositivo fin da subito allo sviluppo del progetto stesso, facendosi carico del coordinamento di uno dei Sub-Task.
In generale, lo scopo del progetto IEA-ECBCS Annex 53è l'approfondimento dei metodi di previsione dei consumi totali e degli usi finali di energia negli edifici, sia con modelli predittivi diretti che indiretti, al fine di identificare e valutare l'efficacia di misure, tecniche e politiche di risparmio energetico applicate a diverse scale di studio, dalla scala del singolo edificio fino a quella grande campione edilizio. A questo si affianca la raccolta e l'analisi critica di esperienze significative per una migliore comprensione del comportamento energetico reale degli edifici.Inoltre, uno specifico approfondimento è dedicato allo studio del comportamento dell'utente e alla determinazione che esso ha sui consumi energetici reali degli edifici.

Introduzione

L'Annex 53 si propone di raggiungereuna migliore comprensione dei dati di consumo energetico reale dei sistemi "edificio-impianti", per la valutazione e lo sviluppo di nuove tecnologie e azioni di risparmio energetico. Rilevante diviene dunque la conoscenza dei principali fattori che influenzano il consumo totale di energia negli edifici e le loro specifiche/reciproche interazioni. Uno degli obiettivi chiave del progetto risulta dunque essere lo studio delle cause principali influenzanti il consumoenergetico,tenendo conto dei fattori attribuibili sia alle prestazioni del sistema edificio-impianto sia al comportamento dell'utente, al fine di prevederne per entrambi gli effetti in edifici nuovi e ristrutturati, nonché il rapporto costi-benefici delle relative misure di risparmio.
Obiettivo ultimo, infine, diviene lo studio di tecniche per la standardizzazione e il benchmarking del consumo totale di energia negli edificio al fine di creare indici sintetici che considerino anche i fattori legati all'utente: ciò dovrebbe consentire anche una più facile comprensione dei sistemi di energylabelingda partedell'utente stesso, favorendo l'informazione sui comportamenti scorretti.
Per raggiungere gli obiettivi sopra illustrati, l´Annex 53 si divide in 4 Subtask:

- Subtask A: Definition and Reporting
- Subtask B: Case Studies and Data Collection
- Subtask C: Statistical Analysis
- Subtask D: Energy Performance Evaluation.

B.1 Comportamento utente: modello per apertura/chiusura finestre

Finalità

Studio e individuazione delle relazioni tra comportamento dell'utente, altri fattori influenzanti e consumi energetici degli edifici con particolare riferimento agli aspetti di apertura e chiusura delle finestre; proposta di un modello analitico.

Azione condotta

Principale obiettivo della taskforceAnnex 53 è la definizione di modelli stocastici del comportamento dell'utente, sviluppati sulla base dell'analisi statistica di data set ottenuti dal monitoraggio della reale interazione uomo-edificio.L'approccio pratico alla modellazione statistica si basa su quattro passaggi operazionali:

1- raccolta dati (oggettivi e soggettivi) provenienti da misurazioni in campo (monitoraggi, questionari);
2- analisi statistica dei dati raccolti e comprensione dei principali parametri influenzanti il comportamento dell'utente (coefficienti e variabili), attraverso la definizione di una curva di regressione logistica;
3- Implementazione della regressione logistica in programmi di simulazione energetica dinamica;
4- Considerazione di una distribuzione probabilistica degli output.

L'apertura e la chiusura delle finestre è stata considerata come input di tipo probabilistico per i programmi di simulazione energetica degli edifici. Per ognuna delle due variabili è stata costruita una funzione di regressione logistica, in seguito implementata nel programma di simulazione energetica dinamica dell'edificio IDA Ice.

B.2 – Comportamento utente: modello per controllo termostato

Finalità

Studio e individuazione delle relazioni tra comportamento dell'utente, altri fattori influenzanti e consumi energetici degli edifici con particolare riferimento agli aspetti di azione sul termostato per il controllo della temperatura ambiente apertura; proposta di un modello analitico.

Azione condotta

Al fine di valutare l'influenza del comportamento dell'occupante sui consumi energetici per il riscaldamento in edifici residenziali, le equazioni di probabilità determinate da studi precedenti per mezzo del software di analisi statistica R, sono state implementate nel programma di simulazione energetica dinamica degli edifici IDA Ice. In particolare, la regolazione del termostato viene descritta da tre differenti funzioni logaritmiche in grado di riprodurre diversi gradi d'interazione dell'utente (attivo, medio, passivo) con il sistema di controllo della temperatura interna.I consumi energetici simulati nel modello deterministico di riferimento (singoli valori di output) sono stati comparati con la distribuzione probabilistica dei risultati ottenuti dalla simulazione dei modelli probabilistici.

Risultati/Deliverable:

- Rapporto tecnico "Modelli descritti del comportamento dell'utente per una migliore previsione dei consumi energetici: apertura/chiusura finestre e controllo del termostato ambiente"
- Rapportotecnico "Driving forces of energy-related behaviour in residential buildings"
- Rapportotecnico"Total energy use in residential buildings – the modelling of occupant behavior"

RESULTS:

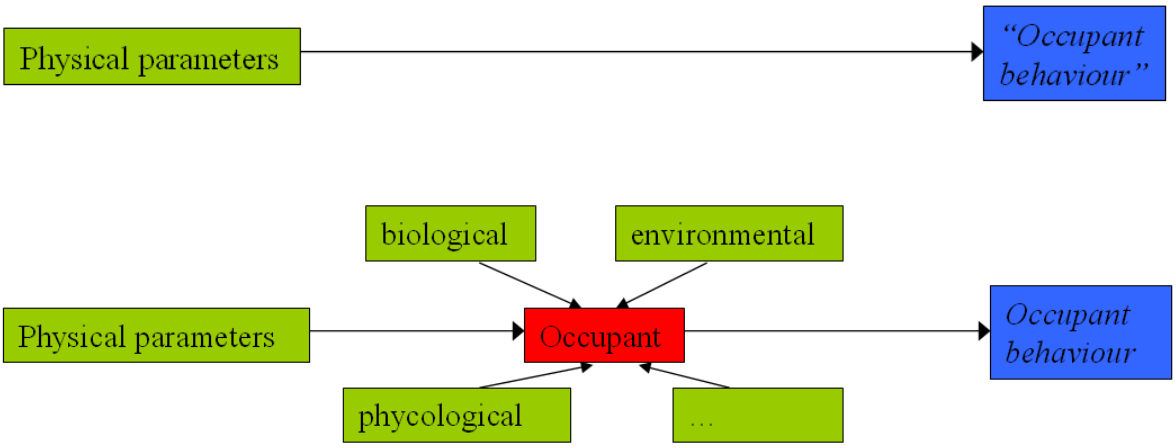
Si riporta di seguito un estratto del Report tecnico "Drivingforces of energy-relatedbehaviour in residentialbuildings" di Annex 53, relativo alla revisione bibliografica dei parametri influenzanti il comportamento dell'utente relativo all'uso di energia negli edifici.

Driving forces of energy-related behaviour

Energy use in residential buildings is influenced by the behaviour of occupants in various ways. Energy-related occupant behaviour is related to building control actions (in order to control the indoor environmental quality) as well as household or other activities. These actions and activities may be driven by various factors.

The influence of occupant behaviour on energy use in buildings has been investigated in various domains: natural sciences, social sciences as well as economics. Many investigations in the natural science literature focus on (statistical) relations between energy-related behaviour and mainly physical factors influencing this behaviour, such as outdoor temperature, indoor temperature and solar radiation.

However, in reality there is no direct relation between e.g. window opening and outdoor temperature. The occupant decides to open or close a window. This decision is based on a number of influencing factors that can be divided in physical environmental aspects, human biological aspects, psychological aspects and the interaction between occupants.



The complex relation between occupants and their environment is worked out in Figure 1. This scheme is based on the presence of the occupant at a specific time at a specific location having access to specific building controls. The occupant experiences a certain physical environment given by his location, and given by his biological and psychological state and by the interaction with his environment.

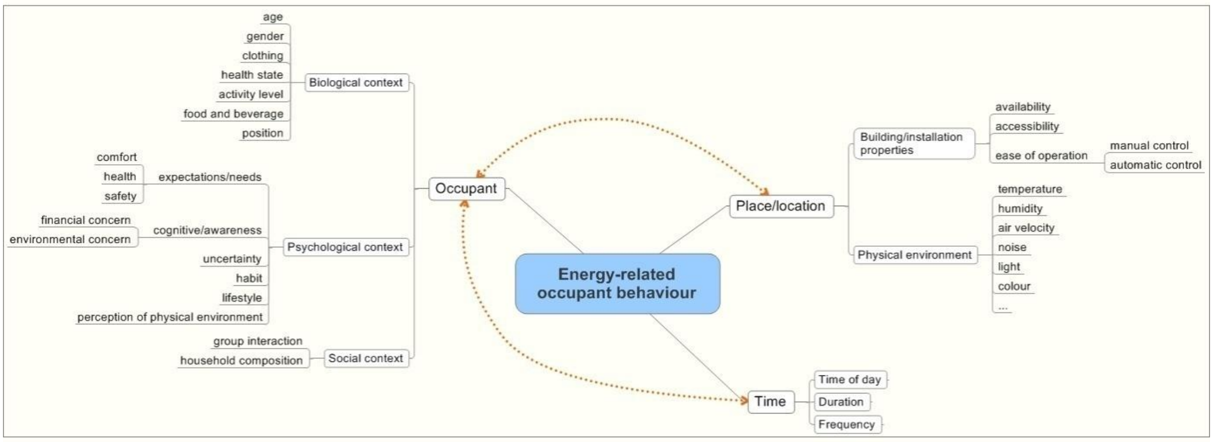


Figure 1: Driving forces of energy-related occupant behaviour.

Information on occupant presence and activities may be obtained from time-use surveys. The interaction between humans and control systems of the building and installations results from a combination of internal and external driving forces. The driving forces of energy-related occupant behaviour as shown in Figure 1 are ordered according to the following categories: biological context, psychological context, social context, time, building/installation properties, and physical environment.

The first three types of driving forces of energy-related behaviour depicted at the left-hand side of Figure 1 (biological context, psychological context, social context), are internal driving forces of the occupant. These are being investigated in the domain of social sciences, economic sciences and biology.

Biological context:
Examples of biological driving forces are age, gender, health situation, clothing, activity level, food and beverage. These factors together determine the physiological condition of the occupant.

Psychological context:
Occupants tend to satisfy their needs concerning thermal comfort, visual comfort, acoustical comfort, health, safety, etc. Furthermore, occupants have certain expectations of e.g. the indoor environmental quality (temperature, etc.). Other examples of psychological driving forces are awareness (e.g. financial concern, environmental concern), cognitive resources (e.g. knowledge), habit, lifestyle, perception.

Social context:
Social driving forces refer to the interaction between occupants. For residential buildings this depends of the household composition (e.g. which household member determines the thermostat set point or the opening/closing of windows).

The external driving forces depicted at the right-hand side of Figure 1 (building/installation properties, physical environment), are being investigated in the field of natural (or building) science.

Building/installation properties:
Examples of building/installation properties are the insulation of buildings, orientation of façades, heatingsystem type, thermostat type (e.g. manual or programmable), etc.

Physical environment:
Examples of physical environment aspects that drive energy-related occupant behaviour are temperature, humidity, air velocity, noise, illumination, and indoor air quality.

The energy-related occupant behaviour block in Figure 1 refers to actions related to the following categories:

- heating (e.g. thermostat set point),
- cooling (e.g. AC operation, shading device operation),
- ventilation and window operation (e.g. mechanical ventilation operation, natural ventilation inlet operation),
- domestic hot water (e.g. shower duration, shower/bath frequency),
- electric appliances and lighting,
- cooking

This behaviour may be usage-related, purchase-related, and maintenance-related. The effects of these actions on residential energy use and indoor environmental quality may be calculated quantitatively using a building simulation software package.

The driving forces for the above mentioned categories of energy-related occupant behaviour will be identified and discussed in more detail in the next sections. The notation used in these sections for the importance of these driving forces is explained in

Table **1**.

Importance	
Description	Symbol
Veryhighlysignificant (p≤0.001)	***
Highly significant (p≤0.01)	**
Moderatelysignificant (p≤0.05)	*
Lowlysignificant (p≤0.1)	’
Notsignificant	No symbol
Notstated	x

Table 1: Notation used for importance of driving forces; p refers to the statistical significance.

Si riporta di seguito un estratto del Report tecnico ““Total energy use in residentialbuildings – the modelling of occupantbehavior”” di Annex 53, relativo al tema della modellazione del comportamento dell’utente per ottenere previsioni di consumo energetico sempre più accurati.

Introduction

As pointed out in the final report of Sub-Task C and in the report Driving forces of energy-related behavior in residential buildings, occupant behavior can affect the energy usage by a magnitude of 3 and above. A wide range of driving forces of energy-related behavior was shown to have a significant influence – these were grouped into biological, psychological, social, time, physical parameters of the environment and the building. This demands interdisciplinary work: engineering and social sciences.

But what is meant by behavior? When it comes to interaction between buildings and human beings, a variety of disciplines is occupied in research on energy-related comfort parameters such as room temperature or indoor air quality. So it is worthwhile to explain how behavior is defined within the topic of this report.

With respect to the energy-related issues of this report, by the term ‘behavior’ is meant the following: observable actions or reactions of a person in response to external or internal stimuli respectively actions or reactions of a person to adapt to ambient environmental conditions such as temperature or indoor air quality or sunlight. In this definition attitudes and motives of a person which lead to a specific action are not included. With respect to the complexity of this issue, beside the models dealing with simulation of energy performance, some psychological models are presented, which show different approaches to explain behavior as a result of decisions, attitudes and habits. Different energy-related behaviour patterns based on different environmental attitudes may play a role in the context of councelling, decision making concerning technical building systems or intervention strategies for households.

Although there are no general differences in scientific principles between natural sciences and human sciences, the integration of different perspectives and vocabulary is not trivial. Nevertheless the goals are ambitious with respect to models at the interface between formalistic parameters and real life processes, especially when human behavior is taken into account.

Models are always a reduction of complexity and abstraction, at the same time it has to be guaranteed that all relevant parameters are considered, namely objective physical (environmental) parameters, personal variables and the interaction between these two sides. The models are translated into computer simulation as a connection of theory and experiment. This includes mathematic-logical processing, by which there might be the risk of overestimating the degree of precision respectively the explanatory power of results.

From the perspective of environmental psychology computer simulation is considered as a helpful method to look at complex systems and to handle practical problems, but the method is applied seldom **Errore. L'origine riferimento non è stata trovata.**. Methodic determinism in the human sciences is often a basis for modeling human behavior, assuming that adequate explanations and regularities of attitudes, intentions and behavior can be found respectively assumed, but "A computer simulation does not necessarily guarantee that a theory is more consistent or comprehensible. Nor does a program's successful performance guarantee that the theory is generalizable, or even that the causes for the success are those predicted by the theory" **Errore. L'origine riferimento non è stata trovata.**.

Computer simulation in the field of user behavior and energy use can serve as an approach to circumstances and practical solutions by visualizing the processes in different energy-related settings. The models can be used as basis for calculation of expected energy consumptions as well as verification of theoretical assumptions about driving factors for energy-related behavior.

Beyond the calculation of energy consumption, the models could show the potential to face practical implications such as the fit between building operation and user behavior (match or mismatch),behavior as basis for building optimization (under which conditions behavior turns into counterproductive behavior?),behavior as a basis for interventions (e.g. information about the building concept, handling of controls as well as training for energy-related behavior).

This reports starts with a discussion of the purposes of modeling occupant behavior when looking at the total energy use of buildings and the categorization of model types. In the following chapters general (psychological) models as well as models applicable to the prediction of total are described. In the last section, summarizing prospects for further research are discussed.

Purpose of modeling and model types

This chapter first discusses purposes of modeling occupant behavior with respect to total energy use in buildings. Based on this discussion, model types usable for the various purposes are defined.

Purposes of modeling occupant behavior

On the most general level, two purposes of modeling occupant behavior can be distinguished: (1) modeling occupant behavior in order to understand driving forces for the behavior itself, and (2) modeling the occupant behavior in order to reveal its relationship to energy demand and usage and the driving forces for variations. Within the framework of this Annex, the second one is the major concern, while the first one might be necessary in order to gain deeper insides into the factors leading to variations in the relationship.

An important question is how much into detail does one have to go to reach the set purpose. This is strongly dependent on the number of buildings, the user profile and the time scale. With respect to the number of buildings, a single object needs to be dealt with differently compared to multiple objects. The user profile can be done for a known user or unknown users and the time scale considered can be short term (, daily, hourly down to fractions of seconds) or long term (season year). The occupant behaviour can be modelled through schedules or diversity profiles (Type A), stochastic models (Type B), or agent based models (Type C).

Table 2 gives an overview of possible objectives for the simulation of occupant behavior together with typical time scales, time steps and preferred behaviour models for single buildings and Table 3 for a group of buildings.

Table 2. Objectives for the simulation of occupant behaviour, time scales and preferred behaviour models for a single building.

	Design			Commisioning		Operation
	Conceptual	Preliminary	Final	Initial	On-going	Control
Aim:	design concept comparison	design optimization	System sizing/ Building code compliance	Initial commissioning	fault detection	Model predictive control
Typical time scale:	season, year	season, year	season, year	?	continuous	1 or 2 days ahead
Typicalt ime step:	1 hour	1 hour	1 hour	1 min, 1 hour	1 min, 1 hour	1 min, 1 hour
Preferred behavior model:	A	A, B or C*	A (B or C*)	A, B or C*	A, B or C*	A, B or C*

* The required model depends on :

The sensitivity of the investigated building performance indicator to occupant behavior. This sensitivity depends on the performance indicator itself (e.g. compare comfort indicators to energy load indicators) and on various building related aspects, among others, building function and user type (e.g. compares schools to offices), building/system concept (e.g. slow responding to fast responding systems) and the degree of which the occupants are able to interact with the building (e.g. operable windows or no operable windows).

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Table 3. Objectives for the simulation of occupant behaviour, time scales and preferred behaviour models for a group of buildings.

	Design			Commisioning		Operation
	Conceptual	Preliminary	Final	Initial	On-going	Control
Aim:	Policy making/ solar/shading analysis	solar/shading analysis	design of electricity grid/ design of district storage	?	fault detection of district storage	District energy storage
Typical time scale:	season, year, 30-years	week, season, year	week, season, year		continuous	1 day ahead, 1 season ahead
Typical Time step:	1 hour	1 min, 1 hour	1 min, 1 hour		1 hour	1 hour
Preferred behavior model:	A	A	A		A	A

Figure 2 gives an overview of additional factors influencing the choice of a model.

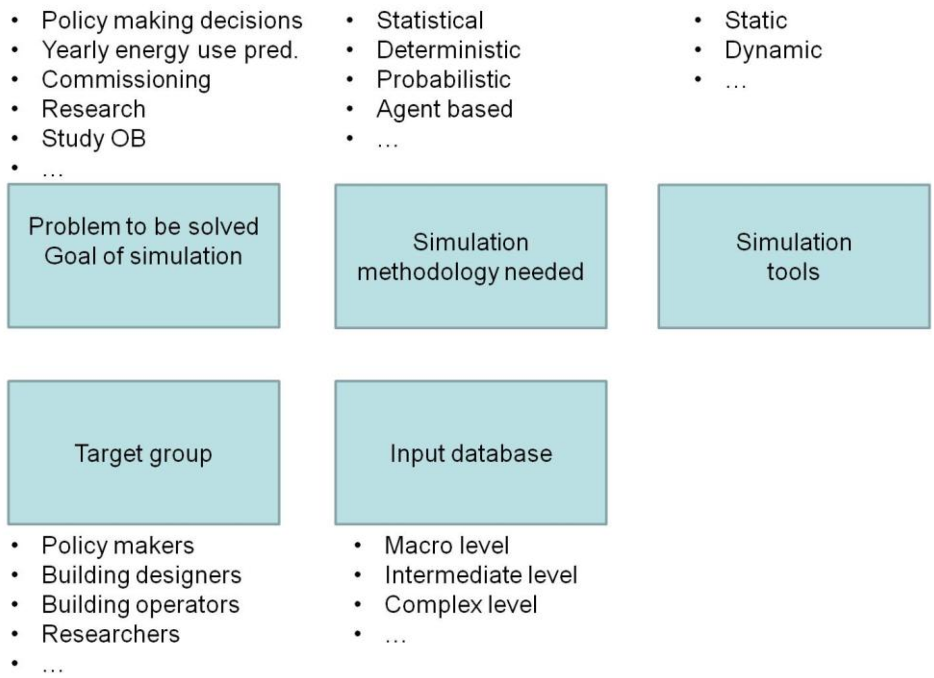

Figure 2. Overview of factors influencing model choice

Definition of model types

In order to clarify the approach used for the following work four basic types of models shall be defined here.

Psychological modelsof occupant behavior can be grouped into those explaining the behavior itself and those related to the energy use in buildings

The use of average valuesis defined by stochastic models based on realistic probability distributions.

Deterministic modelare using predefined typologies of families, which will give deterministic input values for computer simulations.

Probabilistic modelsare defining parameters or equations to evaluate the probability of an action or state.

Agent based modelsaremodelling occupants as individuals with autonomous decisions based on rules and experiences (memory, self-learning)

Pubblicazioni redatte relative al tema

- Effect of occupant behavior related influencing factors on final energy end uses in buildings
  Fabi V., Corgnati S.P., Andersen R.V., Filippi M., Olesen B.W. , Proceedings of Climamed11, Madrid June 2-3 2011.

ABSTRACT

Different aspects are investigated in order to highlight the causes of increased energy consumption in buildings: in particular, the ongoing project IEA ECBCS Annex 53 groups the "influencing factors" into seven major categories empathising the role of occupant behaviour on energy consumptions.
In fact, although building envelope and systems characteristics are known to have a significant effect on energy consumption, their performances can be already assessed in the design phase: and their energy performances have significantly increased in recent years for new and retrofitted buildings thanks to regulations and policies.
At the same time, there has been a shift in the direction of research related to energy and environmental performance of buildings towards a focus on human-centred concerns. One key reason is a greater awareness that these concerns of human well-being are key-parameters in the performance of buildings, as highlighted by the huge gap between real and predicted energy consumptions depending on actual use of the buildings.
Based on a dedicated literature review, the effect of the occupant behaviour on the energy consumptions is here firstly introduced. Then, the influencing parameters affecting final energy end uses (heating, cooling, ventilation, lighting) are presented and critically discussed in order to show the importance of a better description of occupant behaviour in energy prediction tools.

- "Description of occupant behavior in building energy simulation: state-of-art and concepts for their improvement."
  Fabi V., Andersen R.V., Corgnati S.P., Filippi M., Olesen B.W. accepted at 12th International Conference of the International Building Performance Simulation Association. Sydney, Australia, 14-16 November 2011

ABSTRACT

Energy and indoor environmental performance of buildings are highly influenced by outdoor/indoor climate, by building characteristics, and by occupants' behaviour. Building simulation tools cannot precisely replicate the actual performance of buildings because the simulations are based on a number of basic assumptions that affect the results. Therefore, the calculated energy performance may differ significantly from the real energy consumption. One of the key reasons is the current inability to properly model occupant behaviour and to quantify the associated uncertainties in building performance predictions. By consequence, a better description of parameters related to occupant behaviour is highly required. In this paper, the state of art in occupant behaviour modelling within energy simulation tools is analysed and some concepts related to possible improvements of simulation tools are proposed towards more accurate energy consumption predictions.

- Main physical environmental occupant behaviour drivers with regard to natural ventilation
  Fabi V., Andersen R.V., Corgnati S.P., Filippi M., Olesen B.W. accepted at Building Physics Conference2012 , KyotoJapan, May 28-31 2012.

ABSTRACT
Energy consumption in buildings is influenced by building properties, building controls and the way that these are used by the occupants of the building.
This paper focuses on natural ventilation concerning the occupants' habits of opening/closing the windows in residential buildings. Preeminent variables influencing the occupants' use of windows are investigated and the main results of a literature review are highlighted. Statistical analysis of data coming from measurements of occupants' window opening, conducted in 15 dwellings in Denmark, are developed to infer the probability of opening and closing windows and to determine relationships between environmental conditions and the occupants window opening behaviour. The main physical environmental variables that have been found to be important drivers in determining the action to open or close windows are defined on the basis of the measurements.
The ultimate goal is to provide more accurate information about driving forces related to the window opening and closing behaviour.

- Main physical environmental occupant behaviour drivers with regard to space heating energy demand
  Fabi V., Andersen RV., Corgnati SP., Venezia F. Proceedings of 10th International Conference Healthy Buildings, 8th-12th July 2012, Brisbane, Australia.

ABSTRACT
Several studies have highlighted the significant gap between the predicted energy performance of buildings and their measured actual performance. Uncertainties regarding behaviour of building occupants are one of the key factors limiting the ability of energy simulation tools to accurately predict real building energy requirements .
The paper focuses on the particular topics of space heating energy demand related to the occupants habits of adjusting heating set-points. The parameters influencing the user interaction with the heating control system are analyzed in literature for residential buildings, and the resulted influencing factors are illustrated.
Statistical analysis of data coming from measurement carried out in Danish dwellings are performed to infer the probability of adjusting the thermostatic radiators valves and to determine the relationship between the (indoor and outdoor) environmental conditions and the occupants' heating set-point preferences. The paper aims at providing a reliable basis for a more accurate description of control action models in performance simulation applications.

- Influence of User Behaviour on Indoor Environmental Quality and Heating Energy Consumptions in Danish Dwellings
  Fabi V., Andersen RV., Corgnati SP., Venezia F. Proceedings of 2nd International Conference on Building Energy and Environment, 1st-4th August 2012, Boulder, Colorado, US..

ABSTRACT

Models of occupants' interactions with heating controls based on measurements were implemented in a simulation program. Simulation results were given as probability distributions of energy consumption and indoor environmental quality depending on user behaviour. Heating set-point behaviour of 13 Danish dwellings were analysed by means of logistic regression to infer the probability of adjusting the set-point of TRVs. Three different models of occupant's interactions with heating controls were obtained and implemented in a building simulation tool. They were used to investigate how different probabilistic user patterns influence indoor climate quality and energy consumptions. The aim was to compare the obtained results with an actual/deterministic use of the simulation program. Since comfort categories are related to users' expectations and the users' impact is crucial on determining the energy consumption, findings highlight the influence of comfort categories on energy consumption. The probabilistic methodology can be applied in all aspects of user interactions with building controls such as window openings, shading devices, etc. to achieve more realistic predictions of energy consumptions.

- Occupants' window opening behaviour: A literature review of factors influencing occupant behaviour and model
  Fabi V., Andersen RV., Corgnati SP., Olesen BW., Building and Environment (2012), pp. 188-198 DOI information: 10.1016/j.buildenv.2012.07.009.

ABSTRACT

Energy consumption in buildings is influenced by several factors related to the building properties and the building controls, some of them highly connected to the behaviour of their occupants.

In this paper, a definition of items referring to occupant behaviour related to the building control systems is proposed, based on studies presented in literature and a general process leading to the effects on energy consumptions is identified.

Existing studies on the topic of window opening behaviour are highlighted and a theoretical framework to deal with occupants' interactions with building controls, aimed at improving or maintaining the preferred indoor environmental conditions, is elaborated. This approach is used to look into the drivers for the actions taken by the occupants (windows opening and closing) and to investigate the existing models in literature of these actions for both residential and office buildings. The analysis of the literature highlight how a shared approach on identifying the driving forces for occupants' window opening and closing behaviour has not yet been reached. However, the reporting of variables found not to be drivers may reveal contradictions in the obtained results and may be a significant tool to help direct future research.

Appendice

Curriculum scientifico del gruppo di ricerca

Marco Filippi

Marco Filippi, born in 1944, is mechanical engineer and full professor at Politecnico di Torino.
Since 2005 he is Vice-Rector of the Politecnico; before he was member of the Academic Senate (2001-2005), Deputy Dean of the First Faculty of Architecture (2000-2005) and Director of the Interdepartmental Centre for Didactic Services at the Faculty of Architecture (1997-1999).
He acts for the Politecnico di Torino in the executive board of the Centre for Conservation and Restoration of Cultural Heritage "La Venaria Reale" (http://www.centrorestaurovenaria.it).
In the Department of Energy at Politecnico di Torino he leads the research group TEBE (http://www.polito.it/tebe).
TEBE is generally working on energy efficient buildings, indoor environmental engineering, lighting and acoustics and in this context he works on sustainable architecture, technological innovation in building design and energy management in existing buildings.
At the end of the eighties he founded the Laboratory for Environmental System Analysis and Modelling (LAMSA). In 2000 he founded the Centre for Research and Experimentation in Natural and Artificial Lighting (CERSIL) at Environment Park, a scientific and technological park in Torino; in the centre the first Italian "artificial sky" is operating.
He acts for Italy in the Air Conditioning Commission of the International Institute of Refrigeration and in the Annex 53 "Total Energy Use in Building - Analysis and Evaluation Methods" of the International Energy Agency.
He is member of the scientific committees of the Superior Institute for Territorial Systems and Innovation SiTI (http://www.siti.polito.it) and of the Green Building Council Italia (www.gbcitalia.org).
Already member of the scientific committee of the centre "Gino Bozza", in the national council for research CNR ("Consiglio Nazionale delle Ricerche"), concerning causes of deterioration and methods of conservation of the works of art, in 1999 he was selected as member of the team, created by the ministry for the conservation of cultural heritage (Ministero per iBeni e le Attività Culturali), for the definition of guidelines about standards for management and development of the Italian museums (D.M. 10 maggio 2001). At present he is member of the regional committee for the application of the quality standards in museum buildings.
He is author and co-author of over three hundred and fifty scientific papers, didactic papers, chapters of books and editorials.
He is co-editor of the books "Impianti di climatizzazione per l'edilizia: dal progetto al collaudo (HVAC installations in buildings: from design to commissioning)", printed by Masson in 1997 and fully diffused in the Italian community of HVAC designers, "Agenzia Torino 2006_Progetti" and "Agenzia Torino 2006_Cantieri e Opere", printed in 2004 and 2006 by Electa-Mondadori on the occasion of the 20th Winter Olympic Games, and "Certificazione energetica e verifica ambientale degli edifici (Energy certification and environmental assessment in buildings)", printed by Flaccovio in 2007.
He is director of the book collection on "Energy and Environment" edited by CELID (Torino).
Since 1993 to 1995 he was editor of the monthly magazine "Condizionamento dell'aria (Air conditioning)" and at present he is member of the editorial board of the International Journal of Building Science and its Applications "Building and Environment" edited by Elsevier.
In Politecnico di Torino he teaches building physics and building services in the First Faculty of Architecture and he is director of the Doctorate "Technological Innovation in Built Environment".
Since 2003 to 2006 he was director of the Master "Facilities Management for real estate" organized by the Consorzio per la Ricerca e l'Educazione Permanente (COREP).

In the last years he gave lectures on building physics, sustainable building, indoor environment control for human comfort and cultural heritage conservation, building services in historical buildings in degree and doctorate courses, masters and postgraduate schools in Italy.
In the past he worked as HVAC designer. At present he operates as consulting engineer as regards efficient use of energy, indoor environment engineering and technologies for preservation of architectural and artistic heritage. In this context he is frequently charged by public and private bodies as supervisor of building design and construction processes and facilities management contracts.
He is also scientific director of the company Onleco (www.onleco.it), born (2001) in the Incubator I3P of the Politecnico di Torino and which is active in the fields of acoustics, lighting, energy management, indoor environment monitoring, HVAC commissioning and sustainable building.
From 1990 to 1992 he was president of the Società degli Ingegneri e Architetti in Torino (SIAT), a society of engineers and architects established in Turin in the second half of the XIX century.
From 1993 to 1995 he was president of the Associazione Italiana Condizionamento dell'Aria Riscaldamento Refrigerazione (AICARR), the Italian society of the engineers involved with air conditioning, heating and refrigeration and president of the national standard committee for air conditioning and refrigeration.
He is honorary member of AICARR, member of the American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE), and member of Italian societies in the fields of thermal engineering, lighting and acoustics.

Stefano Paolo Corgnati

Stefano Paolo Corgnati, graduated with honors in Mechanical Engineering and Ph.D in Energetics, is Associate Professor at the Energetics Department of the Politecnico di Torino, where he teaches building physics, building energy systems and sustainable building design at the 1st Faculty of Architecture.He works in the TEBE research group (www.polito.it/tebe) focusing on energy&buildings and indoor environmental control.
He is Vice-President of Rehva (Federation of HVAC European Associations) and member of Rehva Board of Directors.
He is member of the Directive Board of AICARR (Italian Association of Air Conditioning) and AICARR delegate for relations with Rehva.
He is the author of more than 180 scientific, technical and didactic publications, mainly concerning: radiant panels technologies, objective and subjective assessment of indoor environmental comfort, thermal mass activation techniques, energy certification and demand of existing buildings. For the quality of his research activity, he won in 2009 the Rehva "Young Scientist Award". Moreover, in 2011 he was nominated "Rehva Fellow".
He is involved in a number of National, European and International Research Projects on building energy consumptions.
He is sub-task leader of the research project Annex 53 "Total Energy Use in Buildings" of the International Energy Agency (IEA-ECBCS). He is chair of the REHVA Task Force on "Indoor Climate Quality Assessment".
He is the operative manager of the Research Competence Centre TI-Green of Politecnico di Torino & Telecom about smart energy monitoring in buildings.
From 2008 to 2010, he was member of the Editorial Board of the Journal "CDA" (Condizionamento dell'Aria, Air Conditioning) and of the following "AICARR Journal", official journals of AICARR.
In 2009 and 2010, he was coordinator of the working group of Politecnico di Torino aimed at supporting Piedmont Region for the implementation and application of Building Energy Certification.

Valentina Fabi

Valentina Fabi, graduated in Architecture (Building) in 2008, is actually a PhD student at the Energetic Department of the Politecnico di Torino. She works in the TEBE research group (www.polito.it/tebe) focusing on the influence of occupant behavior on energy consumption and indoor environmental quality.

She is collaborating with Danish Technical University (DTU), where she spent part of her course of study for eight months.
She is author of 11 scientific and technical publications, including national and international journals, international conferences and chapters of books. Her studies, focused in the beginning on the microclimatic quality in indoor environment, especially in museums, are now focusing on the study related to the occupant behavior in buildings, with the aims of a better prediction of the building performances.
She is partner of the research project Annex 53 “Total Energy Use in Buildings” of the International Energy Agency (IEA-ECBCS) and she is collaborating in team of task-force related to the “Occupant behavior” and Sub-Task C “Statistical analysis”.
In 2013 she is going to defend a Ph.D thesis entitled “The influence of occupant behavior on energy consumption and indoor environmental quality”.

Novella Talà
Novella Talà received the Masters' Degree in Civil Engineering from the Politecnico di Torino in 2003. For the period October 2003-March 2008, she worked for building companies as in construction/building manager.
She is currently an Assistant Researcher with the Department of Energy at Politecnico di Torino. His research activity mainly lies in the area of statistical analysis methods to investigate energy use in buildings and to predict building energy consumptions.
Dr. Talà is coauthor of more than 10 international conference papers and industrial internal reports. She collaborates with ENEA, TELECOM for national projects and with many academic and industrial institutions for the european projects ANNEX, BECA.