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Insights into the effects of occupant behaviour lifestyles and building automation on building energy use

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Abstract

In order to optimize building energy consumption, Member States will have to establish minimum efficiency requirements for systems, and promote the introduction of active control system in new constructions or major renovations. Energy saving, plant efficiency and environmental sustainability are also factors delineating smart buildings. Interestingly, occupant behaviour is known to be one of the key sources of uncertainty in the prediction of building energy use. The success of automation strategies is recognized to be dependent on how the occupants interact with the building. The present research describes the effect of different building occupants' lifestyles and building automation on a high performing building.

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Keywords: Occupant behaviour; smart buildings; subjective questionnaire; dynamic energy simulation; high performing building

1. Introduction

"Home automation", "Building automation" and "Intelligent building" are terms that are getting more and more common in everyday use representing an innovative sector, which continues to grow thanks to the fact that an increasing number of people begin to become familiar with automated devices. This interest is also driven by the potential (energy and cost) savings that these devices are able to achieve thanks to an optimization of the building operation, always oriented at obtaining at the same time optimal comfort conditions. Automation, control and supervision systems can have a significant impact on the energy performance of buildings and on the comfort of their occupants, in particular, they can reduce the consumption of buildings from 10% up to 50% [1]. Therefore, the

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European Committee for Standardization issued the EN 15232 Standard: Energy Performance of Buildings - Impact of Building Automation, Controls and Building Management for use in conjunction with their Energy Performance of Buildings Directive (EPBD) in order to encourage the implementation of these systems. These documents define conventions and methods for estimating the impact of building automation and control system (BACS) on the building energy performance. In the context of nearly-zero energy buildings (nZEBs), the nearly zero or very low amount of energy required should be covered significantly by energy from renewable sources, including renewable energy produced on-site or nearby. In this framework, the building automation could help to reach the nZE level, or rather decrease the building energy demand by balancing energy losses, internal gains and energy needs, with particular regard to the optimization of the balance between heating and cooling needs. Effective control of the heating, ventilation and air conditioning systems in a building is essential to provide a productive, healthy and safe working and living environment for the occupants. Along with high performing building design and efficient HVAC systems, the building control systems play a vital role in the prevention of energy waste and the reduction of the environmental impact of the building. Controls and building automation used in buildings range from simple thermostatic radiator valves, automatic balancing valves, automatic air damper, thermostats and schedulers to building automation and control systems (BACS), building management systems (BMS), also known as building automation system (BAS), energy management systems (EMS) and building energy management systems (BEMS). In the more complex forms, BMS and their related subsystems may have many thousands of data points controlling non-residential buildings and dispersed estates. Residential controls traditionally have a single room thermostat controlling the boiler and pump on/off, a scheduler to set the stop and start times for heating and domestic hot water systems plus thermostatic radiator valves for room temperature control. More sophisticated controls are available for residential and small non-residential buildings, including weather compensation, wireless zone-control systems, and home automation systems that can include curtain activation and audio-video systems, fire alarm and security system. The aim of this research is to demonstrate how the balance between the use of automated systems in a residential environment and an aware occupant interaction with the building and installed systems can lead to significant energy savings. The energy behaviour of a real residential nZEB located in the Northern part of Italy was simulated studying the variations on the obtained energy performances by changing the assumptions related to the users' behaviour. Two user profiles were used: a "standard consumer" (SC) as defined in the EU standards and identified for the standard lifestyle pattern and a "low consumer" (LC) identified as a "sustainable" lifestyle, corresponding respectively to a major interaction and a minor interaction with the building system. Preferences in terms of window opening were defined by analysing an international questionnaires database.

1.1. Technical building management and BACS efficiency classes

EN 15232 standard [2] was created to assess the impact of the building automation on the energy performance of buildings, both in the operational stage and design or retrofit stage. This standard allows estimating the energy savings achieved by automating control functions such as: heating and cooling, ventilation and air conditioning, and blind control. Building automation and controls can have Technical Building Management (TBM) functions, as described in EN 15232, as part of Building Management (BM) that provide information about operation, maintenance, services and management of buildings, especially for energy management – measurement, recording trends, alarming capabilities and diagnosis of energy use. The energy management provides requirements for documentation, controlling, monitoring, and optimisation and supports continuous corrective actions to improve the energy performance of buildings. EN 15232 defines four different building automation and controls classes (A, B, C, D) of functions both for non-residential and residential buildings:

- Class D corresponds to non-energy efficient BACS.– BACS is in class D if the minimum functions of class C are not implemented;
- Class C corresponds to standard BACS – minimum functions shall be implemented (e.g. emission control, control of distribution network, interlock between heating and cooling control of emission and/or distribution);
- Class B corresponds to advanced BACS with some specific functions and TBM;
- Class A corresponds to high-energy performance BACS and TBM – Technical building management function shall be implemented in addition to class B. Room controllers shall be able to demand control building services (e.g. adaptive set point based on sensing of occupancy, air quality, etc.) including additional integrated functions