Automated window opening control system to address thermal discomfort risk in energy renovated dwellings. Summertime assessment.

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SUMMARY

Major and deep energy renovations of single-family houses (more than 60% of the building stock) are expected in Europe over the next several years (Psomas et al., 2016a). A number of research projects have documented and verified overheating risk during the design and operation phase in nearly zero energy or existing renovated single-family houses without mechanical cooling systems in temperate climates. Post occupancy surveys and comfort studies have also monitored high indoor temperatures over 27°C and 28°C even in Northern countries (Psomas et al., 2016a). The main reasons of the thermal discomfort during the cooling period and transition months are the improvement of the airtightness, the increase of the outdoor temperatures (climate change and heat island effects) and the large south-oriented facades (Psomas et al., 2016a). For building occupants of these climates, overheating risk is a new challenge that they have never experienced before now. Users do not have the technical knowledge of how to efficiently decrease the risk, and their attitude and behaviour increase the problem (Psomas et al., 2016a). Health research shows that high indoor temperatures for extended periods significantly degrade the indoor environment and increase the morbidity and mortality.

Ventilative cooling through natural opening systems can be an energy-efficient, sustainable and inexpensive solution to avoid overheating occurrences in energy renovated dwellings in temperate climates (Psomas et al., 2016b). Ventilative cooling through manual control of the opening systems cannot ensure indoor environmental conditions inside the national regulations and comfort standards limits (major violations and poor air quality; Psomas et al., 2016b). Automated window opening control systems with rule based control (RBC) and integrated straightforward heuristic algorithms are already the industry standard for non-residential large-scale buildings.

Psomas et al. (2017) have developed and presented in detail a new automated window opening control system with integrated passive cooling methods and control strategies and real-time monitoring of the environmental parameters indoors and outdoors (temperature, carbon dioxide concentration and relative humidity) for residential buildings. The analysis directly compares the effectiveness of the manual control against the automated control of the window openings for an occupied representative deep renovated dwelling, from the 1930s, in temperate climatic conditions and for two complete summer periods (2015 and 2016): one without the automated system implemented (manual use of the windows and mechanical ventilation) and one with the system installed at the roof windows of the house (Psomas et al., 2017). Occupants of the house experienced identical weather conditions for both cooling periods (Psomas et al., 2017). Both dynamic and static thermal comfort and overheating methodologies, metrics and criteria in room, floor and house levels are used to carry out risk assessment. The performance indicators of the indoor air quality are the carbon dioxide concentration and the relative humidity (Psomas et al., 2017).

The indoor thermal and air quality assessments of the case study for both peak summer periods illustrate the fact that active and passive cooling components and systems, if manually controlled, cannot ensure high quality indoor environment (Figure 1). In contrast, the use of the new automated window opening control system may significantly decrease the indoor thermal discomfort assessed by static and dynamic criteria in all rooms without any significant compromise of the indoor air quality (Figure 1). For this case study, the automated system controls only a small part of the available air flow components of the house (roof windows). The low energy use of the

automated system and the total energy savings, more than 95%, from the deactivation of the mechanical ventilation system strengthen and enhance the possibility of use of these systems in the future. The description of the architecture of the components and control strategies and the identified limitations and suggestions after the monitoring campaign of the automated system may be used as a baseline for the development of automated systems applicable to other climatic conditions and building types.

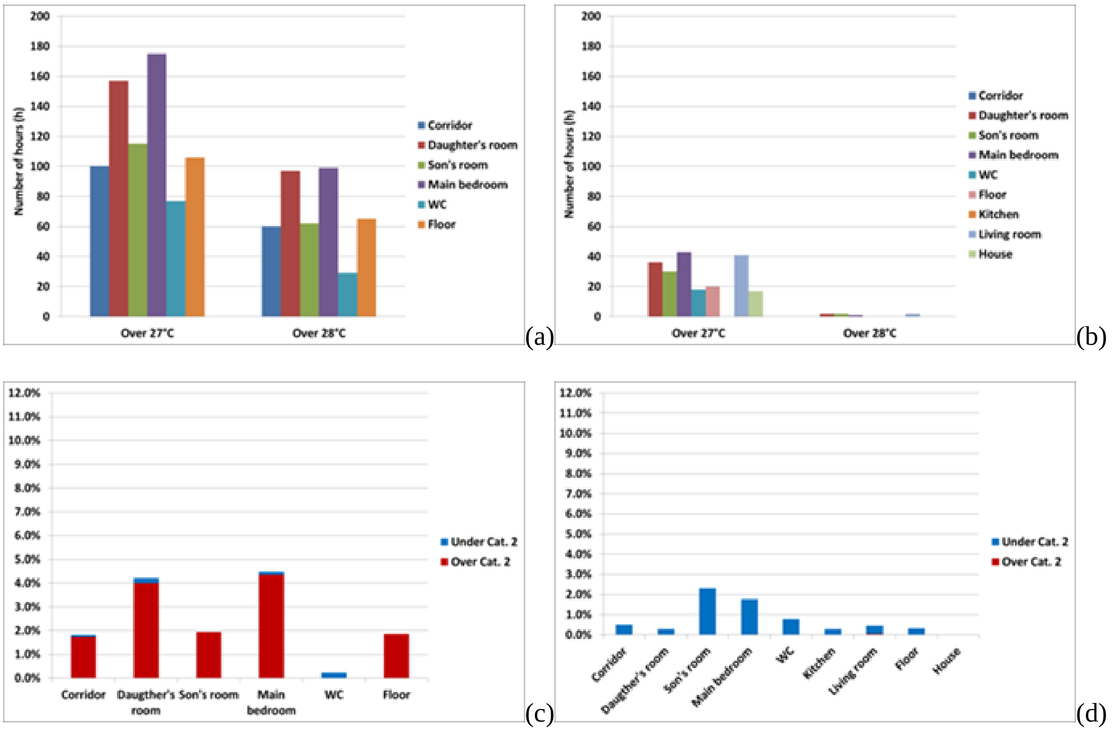

Figure 1: Overheating (a, b) and thermal discomfort (c, d; adaptive method, Category II) assessment in room, floor, and house level of the case study, for summer of 2015 (a, c) and 2016 (b, d).

KEYWORDS

Overheating, residential building, passive cooling, adaptive comfort, indoor air quality.

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