A: Design & technology
A.1. Human centred design solutions

SLEEPING IN AN ACTIVE HOUSE: THE OCCUPANT'S EXPERIENCE

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INTRODUCTION

In a residential building, sleeping is, looking at the time involved, the most important activity of the occupants. For example, in the national time use survey of the US, adults indicate that they spend 8.7 hours a day asleep (Basner, Fomberstein et al. 2007). Assuming all sleep is done in the bedroom, for people with fulltime jobs this accounts for 60% of the total time spent at home (Laverge, Delghust et al. Under Review). None the less, optimizing the indoor environment for maximum sleep quality has received surprisingly little attention in literature and practise, leading to substandard indoor environmental quality in bedrooms in many cases (Beko, Lund et al. 2010, Laverge, Delghust et al. 2013). Although there has some attention to innovative solutions to improve this, these solutions are mainly focused on technical aspects (Pan, Chan et al. 2012, Dongmei, Shiming et al. 2013, Lee, Park et al. 2013, Laverge and Janssens 2014, Spilak, Boor et al. 2014). There is, however, still a dire need of data on occupant responses to indoor environmental conditions during sleep, especially in naturally ventilated situations.

The Model Home 2020 project sought to create a series of 'living labs' for dwellings based on the ‘Active House’ vision and Specification (Active House, 2011), including natural ventilation in summer and mechanical ventilation in winter. The houses were constructed along the principles outlined as the state of the art on indoor environmental performance based on a number of expert panel colloquia. Most of them have now been occupied and monitored for 1 or several years. In this paper we present the results of the monitoring campaign in the bedrooms along with subjective perceptions of the occupants about their sleep quality based on surveys.

METHODOLOGIES

Five ‘Active Houses’ have now been constructed. The oldest one was completed in 2011 and has been inhabited since, the newest one has been inhabited since 2013. In the dwellings, indoor temperature, indoor carbon dioxide, electrical lighting use, energy use and window opening behaviour are monitored. The occupants are also asked to report their experiences in a blog and are subjected to 4 surveys, asking them about their appreciation of the indoor environment, one in winter, spring, summer and autumn.

RESULTS AND DISCUSSION

Figures 1. and 2. show measured temperatures and CO_2 levels. The temperature is above category 1 for 3% of the hours, and above category 2 for 1% of the hours. The 28% hours with temperatures below category 1 during winter are caused by user preference. CO_2-levels in the bedroom during night (sleep hours) average 600 ppm in the summer, and 800 to 1100 ppm in winter (with a mechanical ventilation system commissioned and tested to achieve building code requirements).

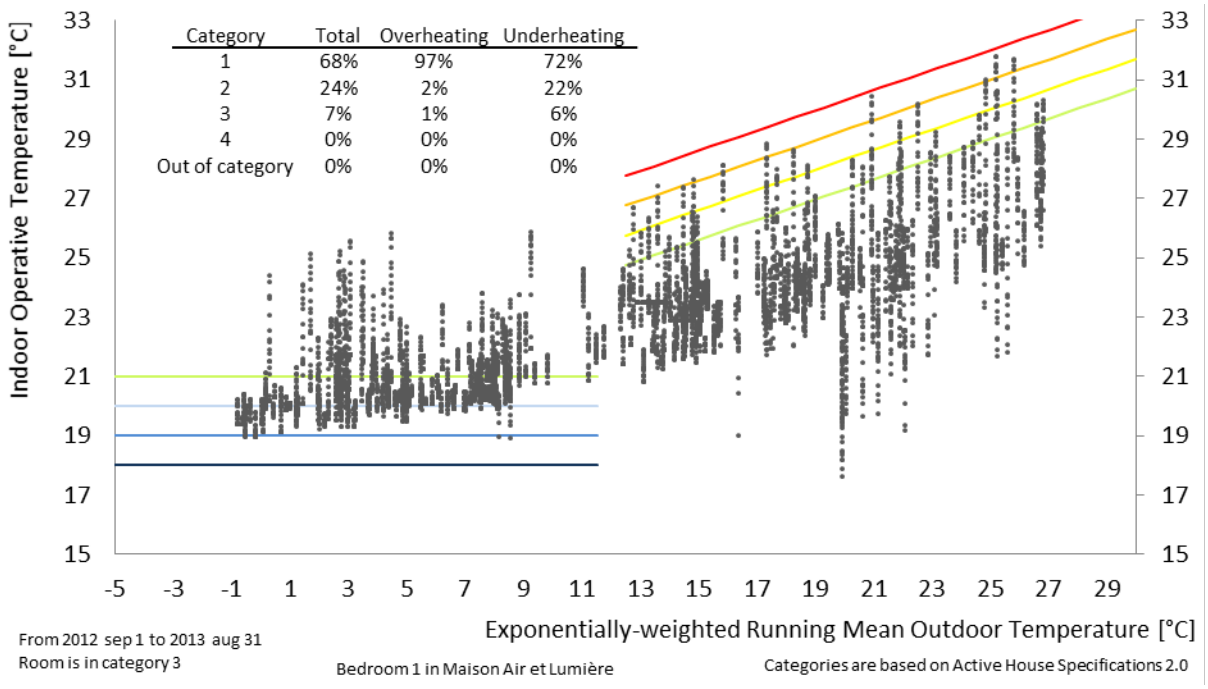

Figure 1. Measured temperatures in the master bedroom of the Maison Air et Lumiere, active house n°3, and evaluated in categories according to Active House Specification, based on the adaptive comfort method and criteria from EN 15251.

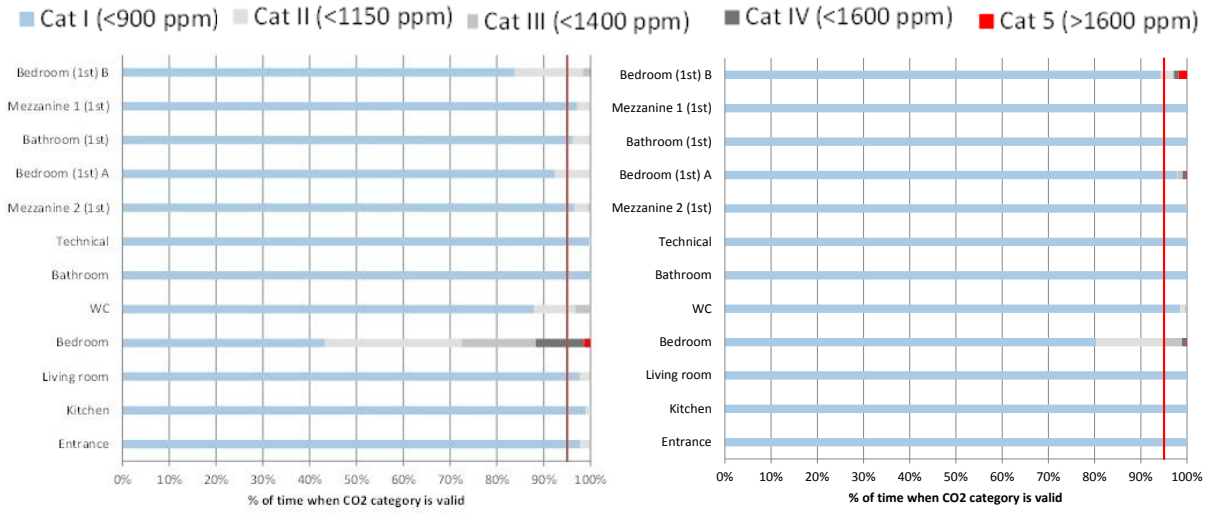

Figure 2. Measured CO_2 levels for January (left) and June (right) in Maison Air et Lumiere, active house n°3, from September 1st, 2012 to August 31st, 2013.

In 50% of the responses, the occupants report that they sleep better than in their former home and they report the IEQ in bedrooms to be 'good', and IEQ in other main rooms to be 'excellent' and much better than in their previous house. This is reflected in the higher CO_2 levels measured in the bedrooms, compared to the other rooms. The CO_2 levels are lowest during summer when natural ventilation is also used for cooling, and highest during winter when mechanical ventilation is the only mean of air change. Specifically on air quality, all responses are either 'very satisfied' or 'satisfied'. Regarding temperatures, 85% of the responses are either 'very satisfied' or 'satisfied', reflected in the limited number of hours above category 1. The occupants rarely report the summer temperatures as too hot. They also report a need for better options to black out light.

CONCLUSIONS

The results show that, when sleep comfort is considered, a number of traditional targets in HVAC design might need to be retaught to characterize the indoor environmental quality of bedrooms: being able to achieve a relatively cool temperature, clean fresh air and deep darkness are relatively more important. To reach these, the design approach for low energy buildings will need to be changed.

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