Perceptions of thermal comfort following deep energy retrofit in social homes in Ireland (HAVEN)

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SUMMARY

Research suggests that energy retrofit measures can have a positive impact on temperature, relative humidity, and can reduce the occurrence of damp and mould (Wang et al., 2022, Fisk et al., 2020). Furthermore, energy renovation offers an opportunity to improve living conditions and the health of occupants of social housing by reducing exposure to indoor air pollution and by improving thermal comfort (Wang et al., 2022, Patino and Siegel, 2018). However, within the extant literature, studies examining occupant-reported thermal comfort post-retrofit are limited and findings vary. The Health Impact Assessment of Energy Renovations on Irish Domestic Dwellings (HAVEN), research project aimed to examine both objectively measured indoor thermal conditions (n=14) and the perceived thermal comfort pre and post retrofit in a sample (n=56) of Irish dwellings. In this paper, we outline the changes in energy usage, carbon emissions and perceived thermal comfort, temperature satisfaction and sources of thermal discomfort. This study demonstrates some of the potential co-benefits and challenges associated with energy efficient retrofit to indoor environmental quality.

KEYWORDS

Thermal comfort, retrofit, questionnaire, indoor air quality

1. METHODOLOGY

The study employed a mixed methods approach, combining environmental monitoring of homes and a questionnaire survey. Recruitment for the study was facilitated by Local Authorities, approved housing bodies (AHBs) and private retrofit companies who aided in the identification of suitable homes and the distribution of study materials to potential participants. The inclusion criteria for the study were (1) homes due to receive a retrofit to a minimum of BER B2 standard (2) participants were aged over 18 years (3) informed consent was secured.

Ethical approval for this project was granted by the University of Galway Research Ethics Committee (Ref:2020.03.009).

1.1 Environmental Monitoring

At the pre-retrofit stage, 38 out of 300 homes contacted, agreed to participate. In total, 14 homes participated in both the pre- and post-retrofit environmental monitoring. Within each home, temperature and relative humidity measurements were collected at five-minute intervals. For the majority of homes 40 - 50 hours of data was collected in the main living room and master bedroom, pre- and post-retrofit. Measurements of the thermal environment were collected using a Graywolf TG-502 or Graywolf IQ-610, using a Pt100 sensor (temperature accuracy/uncertainty of ± 0.3°C) and a capacitive detector (RH, accuracy/uncertainty of ± 2.0%), supplemented with measurements made using an ARANET4 Sensor (SHT3x-DIS CMOSens® Sensor Chip, resolution – temp. 0.1°C, RH 1%, accuracy-temperature, 0.3°C RH 3%).

1.2 Questionnaire Survey

A quantitative, multivariate questionnaire survey was designed with reference to the extant literature. The questionnaire included measures of thermal comfort and temperature satisfaction, sources of thermal discomfort, perceived indoor air quality, odour perception and response, observance of mould and/or condensation and noise disturbance. The questionnaire was piloted and feedback was incorporated to improve the questionnaire. At the pre-retrofit stage, 112 out of the 700 homes contacted, agreed to participate in the survey. At the post-retrofit survey stage, 56 (50%) questionnaires were returned, of which 79% of the participating homes were from Local Authorities or AHBs. Pre/post comparisons of survey measures were conducted, employing Chi square, McNemar and Wilcoxon signed rank tests.

2. RESULTS & DISCUSSION

All homes participating in the questionnaire survey had their legacy heating system replaced with a heating pump and most homes received an upgrade to their building envelope (better fenestration, insulation, etc.). The majority of the houses pre-retrofit had a BER C (51%) while post-retrofit most houses (98%) had a BER rating of B2 or higher. Post-retrofit, several improvements related to thermal comfort were observed. Specifically, participants reported improved thermal comfort ($p<0.01$) increased satisfaction with temperature ($p< 0.01$), improved thermal sensation perceptions during hot/warm weather ($p<0.05$) and in cool/cold weather ($p<0.01$) and a reduction in sources of thermal discomfort such as draughts ($p<0.05$), temperature changes between rooms ($p<0.01$) and hot/cold surrounding surfaces ($p<0.05$) and significantly reduced levels of condensation ($p<0.01$). The median reduction in predicted energy use across the 56 dwellings was 184 kWhm-2yr-1 (sd2 144. kWhm-2yr-1), corresponding to median change of 68% and the a median reduction of predicted carbon emissions of 48 kg CO2 m-2 yr-1 (s.d. 43 kg CO2 m-2 yr-1), or 76%. Around a quarter of the homes (26%) experienced mould and condensation issues post-retrofit.

In the homes where environmental monitoring was conducted, a slight decrease in room temperature was observed in both room types, post-retrofit. However, median air temperatures in the bedrooms and living rooms at both pre and post-retrofit were within EN16798 Category

I limits of between 21 and 25.5 °C. Median relative humidity values ranged from 52-62%, both pre- and post-retrofit. Most participants in the environmental monitoring component (85%) expressed satisfaction with the heating in their home post-retrofit, however a minority reported issues with draughts and blocking of air vents was observed during fieldwork (n=5).

3. CONCLUSIONS

Use of questionnaire survey data in conjunction with objective measurement of temperature and humidity pre/post retrofit, offers a more nuanced overview of issues related to thermal comfort that cannot be assessed solely based on monitoring air temperature. This study contributes to the evidence base by demonstrating the additional benefits of energy retrofits to homeowners over and above those related to energy efficiency and also providing valuable insights into occupant concerns and sources of satisfaction.

4. ACKNOWLEDGEMENTS

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5. REFERENCES

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