Investigating the Impacts of New Energy Renovation Strategies on Indoor Environmental Quality

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SUMMARY

There is a pressing need for large-scale energy retrofits in domestic dwellings to reduce carbon emissions. However, these retrofit strategies must be carefully balanced against the embodied carbon, operational energy, and indoor environmental quality in dwellings. This research aims to analyse the implications of indoor environmental quality arising from energy retrofit scenarios in the Irish context. Building physics simulations will determine a range of pre and post-energy retrofit scenarios and address the implications under various scenarios. The data collected will contribute to a larger project investigating the life cycle assessment of these building cohorts.

KEYWORDS

Climate Change, Built Environment, Indoor environmental quality, economic, renovation strategy

1 INTRODUCTION

Climate change is a major concern that is being addressed across various sectors and geographies. The built environment sector consumes considerable energy and is responsible for a large share of total greenhouse gas emissions. As concerns grow towards sustaining the planet, it is imperative that greener and more sustainable strategies are adopted so as to minimise the impacts towards the environment and the human population. The aim of this research as a part of the ENABLE Project is to investigate the impacts that may be caused by new energy interventions on the indoor environmental quality of residential buildings. A life-cycle-based renovation approach is of the utmost importance as energy efficiency and renovation measures that only target the operation phase of buildings (e.g., heating, cooling and lighting) may lead to the selection of inappropriate and more carbon-emitting solutions, which may also impact the indoor environmental quality parameters. Inappropriate retrofit actions can incorrectly consider energy consumption, thermal discomfort, and IEQ in dwellings, highlighting the need for a deeper understanding and better strategies to address these multifaceted issues.

A previous study of 15 Irish dwellings reported that CO2, VOCs, and PM2.5 concentrations significantly increased post-retrofit and were correlated with lower building air

exchange rates (Broderick et al., (2017). These dwellings, constructed according to the 1990 Irish Building Regulations, featured a combination of cavity walls (built-in 2000) and hollow blocks (built in 1994). In another Irish study (Hassan et al., (2024)), a similar increase in PM2.5 and formaldehyde concentrations was observed for deep energy-retrofitted dwellings that ranged in age from 15 to 60 years. Therefore, there is a need for an in-depth analysis of the broad range of factors influencing IEQ during energy retrofit and, in particular, in the context of ventilation.

This research aims to achieve a sturdy balance between improved energy efficiency and maintaining the appropriate levels of indoor environmental quality parameters within domestic dwellings as defined by the respective international and national level organisations. The existing literature indicates that there is no user-friendly decision support tool that can aid residential portfolio owners and policy in choosing the most appropriate renovation strategy complying with the indoor environmental quality parameter standards for different geographical scales and building types. An economical solution that will reduce energy consumption whilst maintaining the relevant indoor environmental quality parameters of a variety of Irish dwellings will be the overarching goal of this study.

2 METHODOLOGY

A number of different types of Irish dwellings will be considered in this study and will analyse the impact of various energy retrofit interventions on indoor environmental quality. BIM-based archetype simulations will be carried out using CONTAM software to perform the indoor environmental quality (IEQ) analysis. The environmental parameters that will be considered will include temperature, relative humidity and the behaviour and distribution of air pollutants such as PM2.5[1], Radon, Formaldehyde, Total Volatile Compounds (TVOCs) and Carbon Monoxide. The simulations will be carried out for both pre and post-energy retrofits to ensure a comparison between the two scenarios for different building archetypes under different ventilation systems and a variety of emission profiles in relation to IEQ and will also consider the utilisation of renewable energy with different occupancy case scenarios. Comparisons will be made for different types of ventilation systems, including, but not limited to, natural, demand control and mechanical systems.

3 EXPECTED RESULTS

The simulations' results will be validated against data collected from previous projects carried out by members of the same research collaborations. The simulations will include a variety of rooms with different dimensions, additional emissions and pollutant cases, various meteorological conditions, occupancy profiles, ventilation, and air-tightness characteristics. Changes in pollutant changes will be mapped against the outputs of Annex86 Subtask 1, and change in DALYs will be determined. Therefore, a sensitivity analysis will be performed to determine the impact of the aforesaid energy interventions and thereby identify any possible high-risk renovation strategies. This will ensure that the proposed renovation strategy will not adversely impact the human population.

4 CONCLUSION

The outputs from the indoor environmental quality assessment will form part of wider a decision-support tool that will enable the relevant stakeholders to select the most appropriate renovation strategy without compromising the indoor environmental quality of domestic

[1] PM 2.5 – Refers to Fine particulate matter with particle diameter size less than or equal to 2.5 micrometres

dwellings. This will support long-term efforts to decarbonise residential buildings with the appropriate indoor environmental quality metrics.

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6 REFERENCES

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