Temperature and CO_2 in Madrid social housing through one year monitored data

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ABSTRACT

Housing energy rehabilitation has become a key priority across Europe, particularly in the context of climate change and social vulnerability, and is aligned with the mechanisms for a just transition under the European Green Deal and the Renovation Wave. In disadvantaged neighbourhoods, improving energy efficiency and indoor comfort conditions has a significant impact on residents' quality of life and well-being, while reducing the risk of energy poverty. However, rehabilitation strategies are often designed based on standardized scenarios, without adequately considering variations related to user behaviour, household composition, or specific building typologies. Systematic monitoring of social housing provides essential data to identify the most effective strategies, grounded in an accurate diagnosis of actual performance rather than theoretical assumptions.

We present the analysis of one year of monitored data on energy consumption, hygrothermal comfort, and indoor CO_2 levels for 22 dwellings located in six vulnerable areas of Madrid. The monitoring campaign covers not only typical weather conditions but also periods of extreme heat and cold, as well as two exceptional events: the "Filomena" snowfall and the COVID-19 pandemic lockdown. These circumstances offer a unique opportunity to assess building performance under stress conditions.

The overall results reveal poor indoor environmental quality in these homes, both in living spaces and bedrooms, alongside evidence of deficient building envelopes. Recorded energy consumption is consistently lower than reference values established by standards or predictive models, achieved at the expense of indoor temperatures outside comfort ranges. Minimum temperatures during cold periods are lower, and maximum temperatures during warm periods are higher in single-person households and in dwellings located under the roof. Higher CO_2 concentrations are associated with higher relative humidity, a greater number of occupants, and longer periods of stay in the dwellings. Indoor conditions in bedrooms differ significantly from those in main living spaces: temperatures are generally lower, while CO_2 concentration and relative humidity are typically higher, with marked seasonal variations. The dataset discussed in this study is available through the following publication: https://doi.org/10.1016/j.buildenv.2024.111354.

Energy renovation strategies for homes rarely include approaches to indoor air management, as natural ventilation is assumed to occur depending on user behaviour. Conversely, improving the building envelope often increases airtightness, which can lead to a deterioration in indoor air quality. The analysis underscores the need for retrofit strategies that integrate household-specific factors—such as single-person households or families with children—the heightened vulnerability of dwellings with greater energy demand, the influence of subjective thermal perception and user behaviour, and the critical importance of improving indoor air renewal systems.

KEYWORDS

IAQ, naturally ventilated dwellings, indoor monitoring, retrofit strategies, social housing