

TOWARDS RESILIENT AND SUSTAINABLE CITIES: EVALUATING THERMAL COMFORT IN A DWELLING IN QUITO, ECUADOR (2024)

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INTRODUCTION

- The climate crisis risks irreversible impacts with temperatures 1.52°C above pre-industrial levels. [1]
- Poverty and weak policies in Latin America hinder resilience progress. [2]
- Urban resilience requires passive and sustainable buildings, where LZEBs (Low or Zero Energy Buildings) reduce emissions. [3]
- In equatorial cities (-23° to 23° latitudes), including the Andean region, seasons are no noticeable, maintaining the daily average temperature nearly constant during the year. In there, bioclimatic strategies, that take advantage of solar radiation and ventilation for thermal comfort permit to eliminate reliance on HVAC systems. [4]

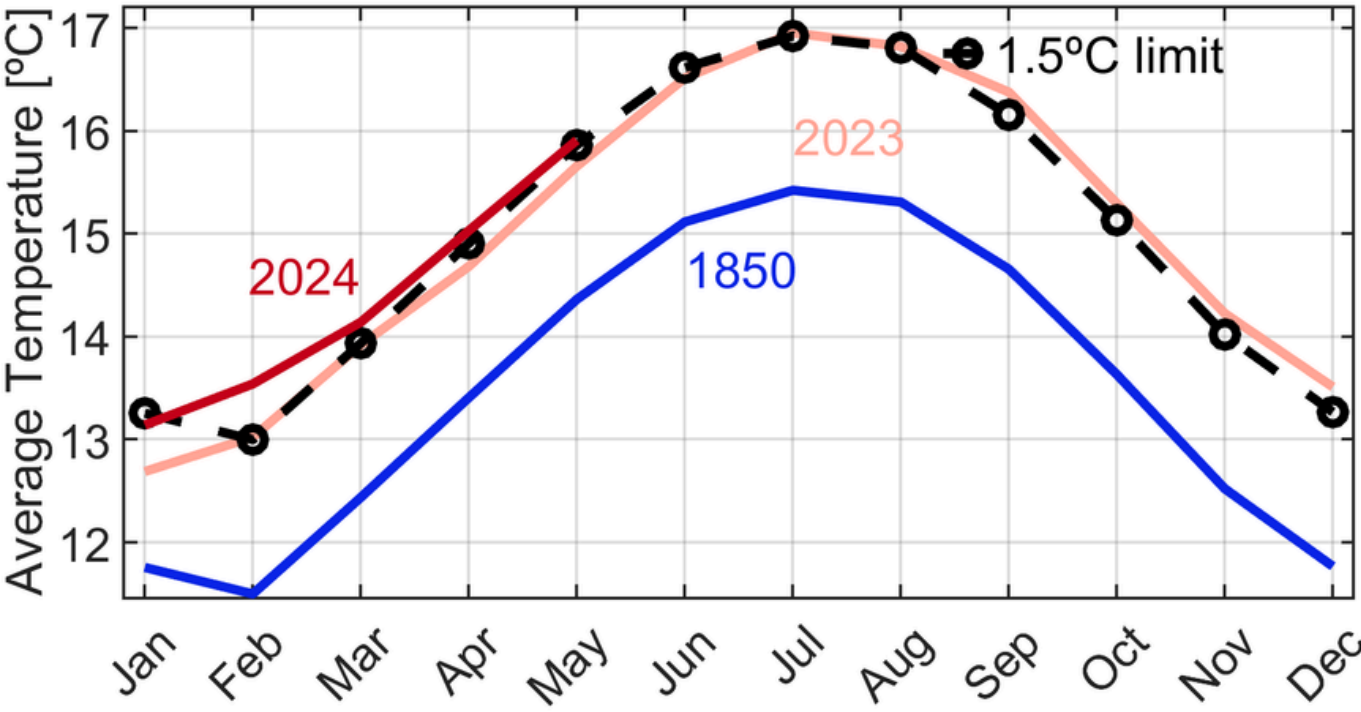


Figure 1. Global mean temperature (°C) for each month of representative years.

The hypothesis states that passive design optimizes comfort and efficiency, and is crucial for resilient cities at an urban scale.

CONCLUSIONS

- General**
- Thermal comfort (69%) is improved through bioclimatic strategies, demonstrating its potential as a scalable strategy for sustainable and resilient urban development and creating a replicable resilient housing model for Andean cities.
- Specific**
- In the Andean region, solar gains are the main source of heat, helping to maintain stable temperatures during cold nights. (I and III)
 - High thermal inertia in the envelope reduces early morning discomfort, achieving up to 82% comfort with passive strategies. (IV)

FUTURE WORK

- This work is part of a broader project focused on the experimental assessment of a resilient dwelling. This dwelling account as main systems: rainwater harvesting, grey water recycling, net zero energy consumption, domestic hot water produced with a heat pump, etc
- The dwelling model is being calibrated, with experimental measurements resulting in promising initial results. It is also collecting temperature and relevant data for further analysis.
- Quantification of the resilience of this dwelling is also being investigated.

METHODOLOGY

A three-story **bioclimatic dwelling** is dynamically simulated using weather data to evaluate thermal comfort over a full year. The design optimizes thermal performance through material selection, while internal gains are modeled based on the habits of four occupants. Metabolic rates, activity levels, and clothing follow ASHRAE HOF standards to assess indoor comfort conditions.

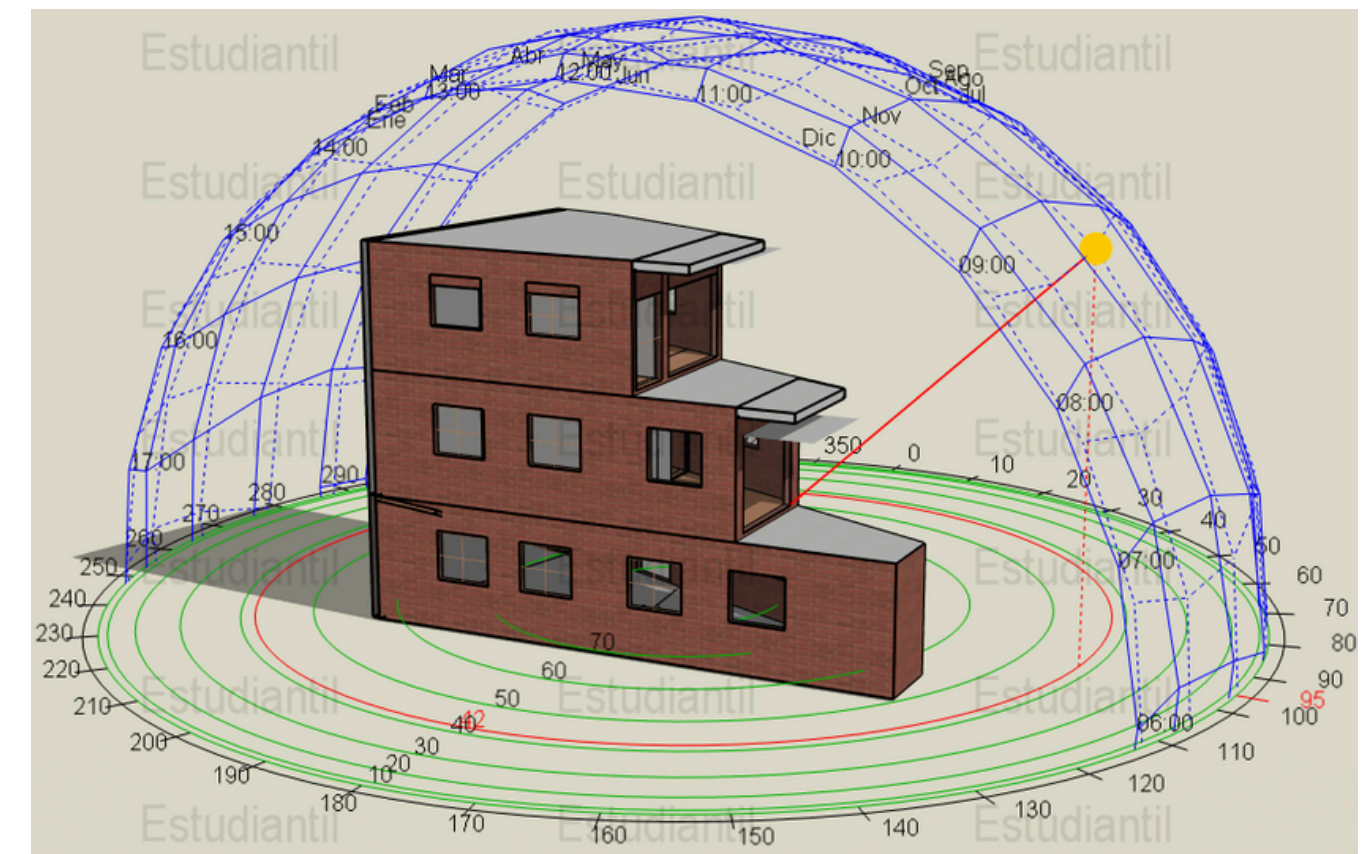


Figure 3. Dwelling model.

Software: EnergyPlus and DesignBuilder
Weather Data: NREL TMY 2022, (March 10, warmest day, and July 28, coldest day)
Internal Gains: Occupancy, lighting, equipment, and natural ventilation based on schedules.
Thermal Comfort: Adaptive comfort model (ASHRAE 55.1), 80% and 90% acceptability.

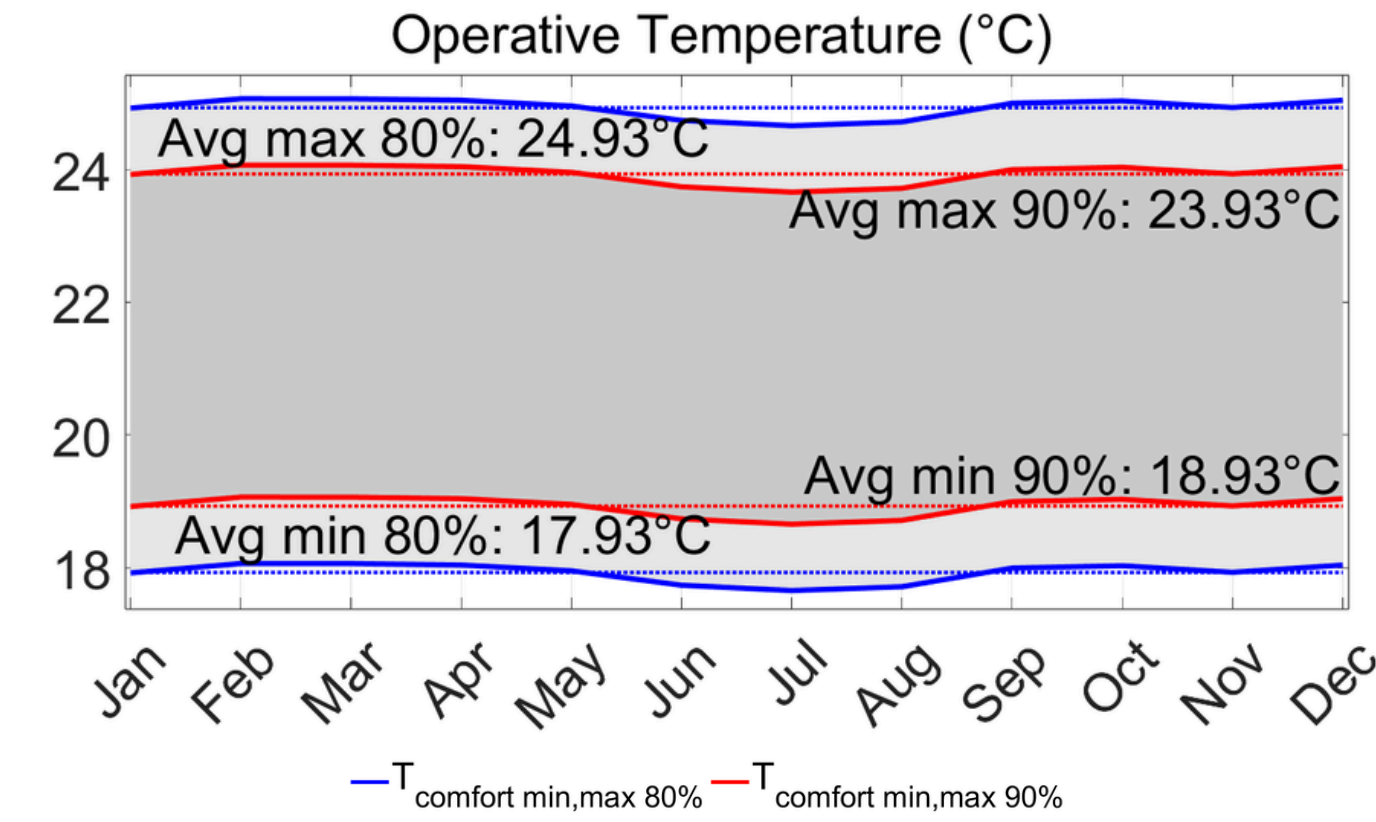
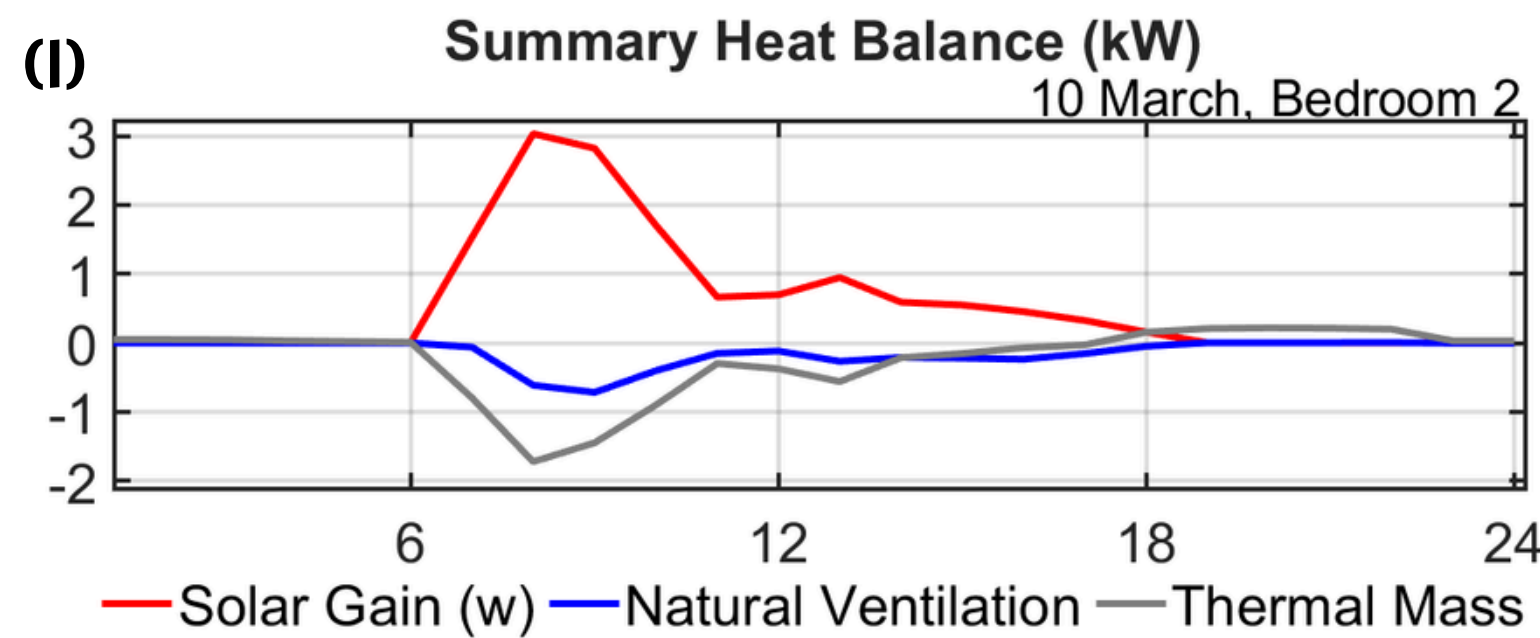


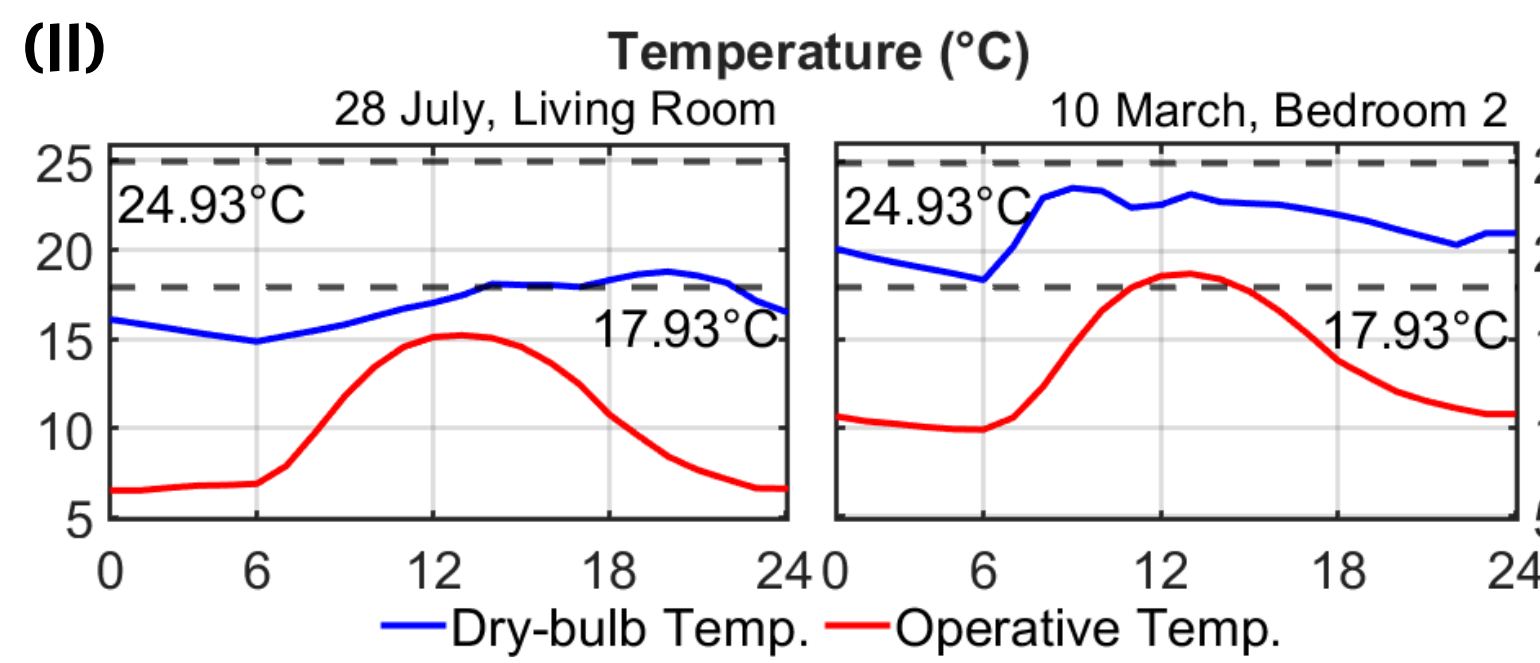
Figure 4. Temperature range for adaptive comfort with 80% and 90% acceptance in Quito.

RESULTS & ANALYSIS

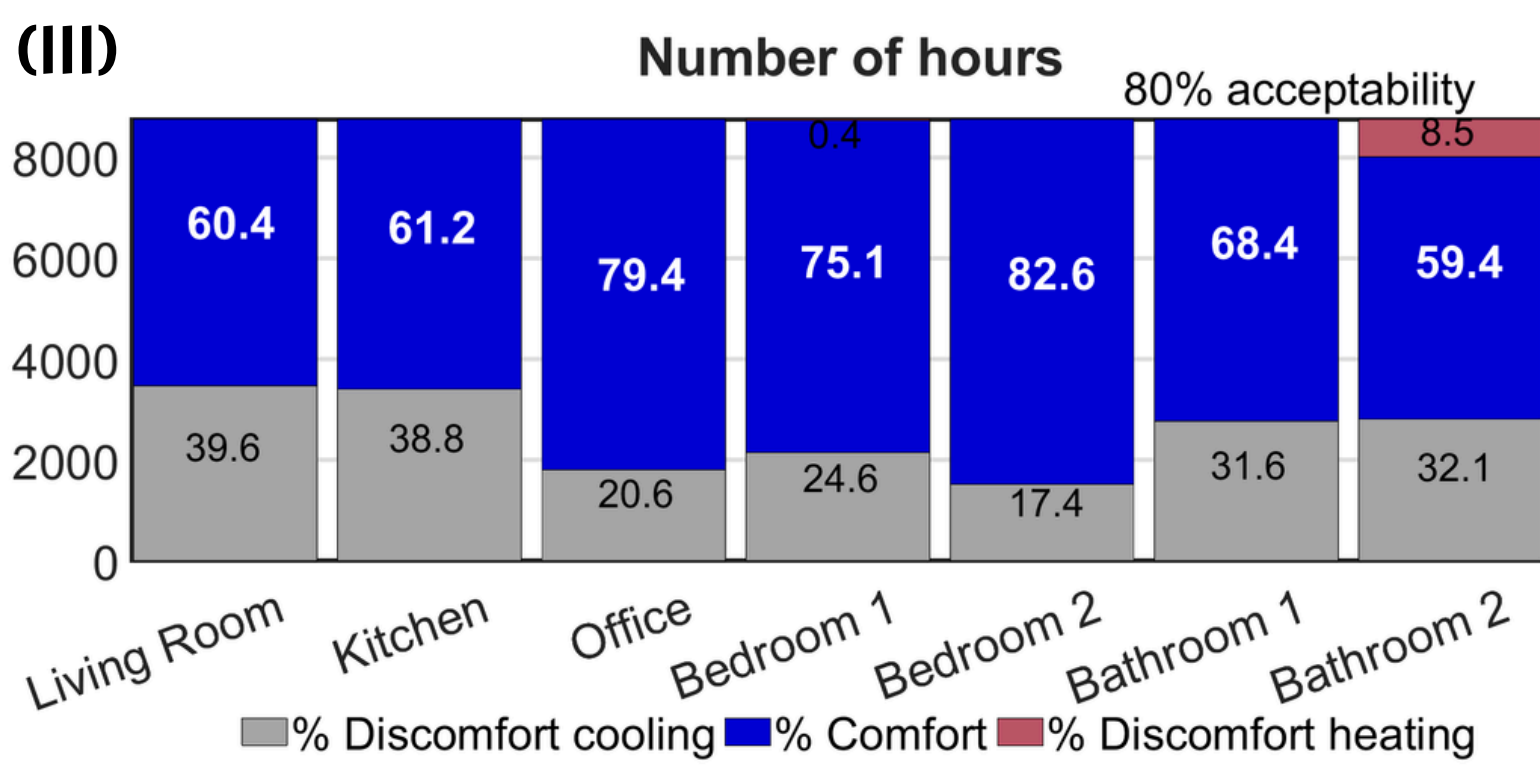
Solar radiation heats surfaces during the day, storing heat that is released at night. Exterior temperatures can drop significantly, causing the interior to cool.



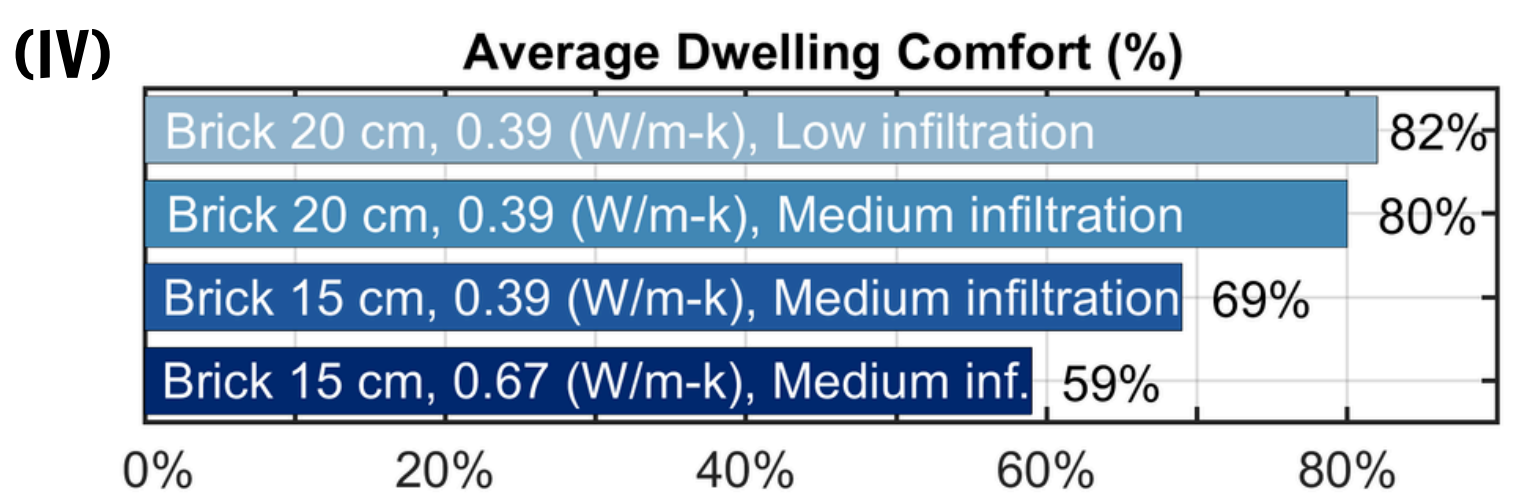
Solar gains are the main heat source, absorbed by thermal mass (walls, floors, and ceilings). Natural ventilation aids temperature regulation, while internal gains remain minimal, reaching only 0.6 kW even in high-activity areas.



On days with high solar radiation, comfort can be maintained throughout the day. On cold days, the **temperature remains stable**, not falling below 15°C, which is an achievement in the Andean region.



The dwelling achieves a **weighted comfort of 69%** with 80% acceptability, and the hours of discomfort are mostly due to cold.



Using a brick with **better thermal conductivity** and minimizing infiltrations by careful construction, the dwelling may achieve up to 82% comfort.

REFERENCES

- [1]The Copernicus Atmosphere Monitoring Service, "2023 is the hottest year on record", 2024.
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[4]R. Pacheco, J. Ordóñez, and G. Martínez, "Energy efficient design of building: A review", 2012.