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Editorial

Energy Implications of Thermal Comfort in Buildings Considering Climate Change

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Extreme weather events and rising global temperatures are signs of the urgent threat that climate change poses to our planet [1]. Energy used for heating, cooling, and sustaining thermal comfort in buildings is a crucial factor in causing this issue [2]. It is crucial to look at the energy implications of attaining thermal comfort in buildings in the context of climate change as the world struggles with the urgency of lowering greenhouse gas emissions [3].

An essential component of human wellbeing, thermal comfort has a direct bearing on our level of well-being and productivity [4]. A comfortable interior atmosphere is provided by buildings, which normally maintain a temperature range between 20 and 25 °C. However, it is becoming harder to sustain thermal comfort in the face of climatic change. Temperature extremes become more frequent and intense due to climate change, requiring more energy to cool spaces [5]. In a vicious loop, increasing energy demand exacerbates greenhouse gas emissions, which worsen climate change. The traditional fixed-temperature approach to thermal comfort is challenged by the idea of adaptive comfort, which is especially relevant considering climate change, given the energy-saving opportunities it promises in present [6] and future scenarios [7]. It implies that people can adjust to a wider range of temperatures and their comfort temperature changes depending on the outdoor temperature fluctuations of the previous days [8,9]. Encouraging tenants to adopt new habits, such as using fans instead of air conditioning, can cut energy usage [10].

To reduce the energy implications of thermal comfort, building design is crucial. Innovative design techniques can lessen the need for mechanical heating and cooling, such as passive solar design [11] and green roofs [12]. The reduction in energy use also depends on improvements in building materials and technology, such as energy-efficient HVAC systems [13] and smart windows [14].

To reduce buildings' carbon impacts, we must switch to renewable energy sources. The use of fossil fuels may be decreased using sustainable energy sources for heating and cooling, such as solar panels [15], wind turbines [16], and geothermal systems [17]. Smart grid technology can optimise energy use and lower peak demand [18].

Promoting energy-efficient construction practises heavily depends on government regulations and incentives. The battle against climate change must include creating laws requiring better energy efficiency requirements, tax incentives for green construction practises, and financial support for renewable energy installations [19].

In the context of climate change, the energy implications of maintaining thermal comfort in buildings cannot be overstated. Cooling-related energy demand will keep rising as temperatures rise and severe weather events become more common, boosting greenhouse gas emissions. A multifaceted strategy incorporating creative building design, behavioural modifications, the integration of renewable energy sources, and helpful regulations is needed to overcome this situation. To create sustainable solutions prioritising both human satisfaction and environmental responsibility, researchers, architects, legislators, and the general public must work together to lessen the energy costs associated with maintaining

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thermal comfort in buildings, cut down on carbon emissions, and construct a more resilient and sustainable future in the face of climate change.

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References

1. Meinshausen, M.; Smith, S.J.; Calvin, K.; Daniel, J.S.; Kainuma, M.L.T.; Lamarque, J.; Matsumoto, K.; Montzka, S.A.; Raper, S.C.B.; Riahi, K.; et al. The RCP Greenhouse Gas Concentrations and Their Extensions from 1765 to 2300. *Clim. Change* **2011**, *109*, 213–241. [CrossRef]
2. Yang, L.; Yan, H.; Lam, J.C. Thermal Comfort and Building Energy Consumption Implications—A Review. *Appl. Energy* **2014**, *115*, 164–173. [CrossRef]
3. Sánchez-García, D.; Rubio-Bellido, C.; del Río, J.J.M.; Pérez-Fargallo, A. Towards the Quantification of Energy Demand and Consumption through the Adaptive Comfort Approach in Mixed Mode Office Buildings Considering Climate Change. *Energy Build.* **2019**, *187*, 173–185. [CrossRef]
4. De Dear, R.J.; Akimoto, T.; Arens, E.A.; Brager, G.; Candido, C.; Cheong, K.W.D.; Li, B.; Nishihara, N.; Sekhar, S.C.; Tanabe, S.; et al. Progress in Thermal Comfort Research over the Last Twenty Years. *Indoor Air* **2013**, *23*, 442–461. [CrossRef] [PubMed]
5. Holmes, M.J.; Hacker, J.N. Climate Change, Thermal Comfort and Energy: Meeting the Design Challenges of the 21st Century. *Energy Build.* **2007**, *39*, 802–814. [CrossRef]
6. Bienvenido-Huertas, D.; Rubio-Bellido, C.; Pérez-Fargallo, A.; Pulido-Arcas, J.A. Energy Saving Potential in Current and Future World Built Environments Based on the Adaptive Comfort Approach. *J. Clean. Prod.* **2020**, *249*, 119306. [CrossRef]
7. Bienvenido-Huertas, D.; Sánchez-García, D.; Rubio-Bellido, C. Influence of the RCP Scenarios on the Effectiveness of Adaptive Strategies in Buildings around the World. *Build. Environ.* **2022**, *208*, 108631. [CrossRef]
8. De Dear, R.J.; Brager, G.S. Developing an Adaptive Model of Thermal Comfort and Preference. *ASHRAE Trans.* **1998**, *104*, 145–167.
9. McCartney, K.J.; Nicol, J.F. Developing an Adaptive Control Algorithm for Europe. *Energy Build.* **2002**, *34*, 623–635. [CrossRef]
10. Knudsen, M.; Rissetto, R.; Carbonare, N.; Wagner, A.; Schweiker, M. Comfort and Economic Viability of Personal Ceiling Fans Assisted by Night Ventilation in a Renovated Office Building. *Buildings* **2023**, *13*, 589. [CrossRef]
11. Askari, M.; Jahangir, M.H. Evaluation of Thermal Performance and Energy Efficiency of a Trombe Wall Improved with Dual Phase Change Materials. *Energy* **2023**, *284*, 128587. [CrossRef]
12. Mousavi, S.N.; Gheibi, M.; Wacławek, S.; Behzadian, K. A Novel Smart Framework for Optimal Design of Green Roofs in Buildings Conforming with Energy Conservation and Thermal Comfort. *Energy Build.* **2023**, *291*, 113111. [CrossRef]
13. Li, Z.; Meng, Q.; Wei, Y.; Zhang, L.; Sun, Z.; Lei, Y.; Yang, L.; Yan, X. Dynamic Room Temperature Setpoints of Air-Conditioning Demand Response Based on Heat Balance Equations with Thermal Comfort Model as Constraint: On-Site Experiment and Simulation. *J. Build. Eng.* **2023**, *65*, 105798. [CrossRef]
14. Hong, S.; Choi, S.; Jeong, S. Building Energy Savings by Developing Complex Smart Windows and Their Controllers. *Appl. Sci.* **2023**, *13*, 9647. [CrossRef]
15. Li, Y.; Jia, Z.; Zhang, X.; Liu, Y.; Xiao, F.; Gao, W.; Xu, Y. Energy Flexibility Analysis and Model Predictive Control Performances of Space Heating in Japanese Zero Energy House. *J. Build. Eng.* **2023**, *76*, 107365. [CrossRef]
16. Assareh, E.; Dejdar, A.; Ershadi, A.; Jafarian, M.; Mansouri, M.; Roshani, A.S.; Azish, E.; Saedpanah, E.; Lee, M. Techno-Economic Analysis of Combined Cooling, Heating, and Power (CCHP) System Integrated with Multiple Renewable Energy Sources and Energy Storage Units. *Energy Build.* **2023**, *278*, 112618. [CrossRef]
17. Mehmood, S.; Lizana, J.; Friedrich, D. Low-Energy Resilient Cooling through Geothermal Heat Dissipation and Latent Heat Storage. *J Energy Storage* **2023**, *72*, 108377. [CrossRef]
18. Charalambous, C.; Heracleous, C.; Michael, A.; Efthymiou, V. Hybrid AC-DC Distribution System for Building Integrated Photovoltaics and Energy Storage Solutions for Heating-Cooling Purposes. A Case Study of a Historic Building in Cyprus. *Renew. Energy* **2023**, *216*, 119032. [CrossRef]
19. Aleluia Reis, L.; Vrontisi, Z.; Verdolini, E.; Fragkiadakis, K.; Tavoni, M. A Research and Development Investment Strategy to Achieve the Paris Climate Agreement. *Nat. Commun.* **2023**, *14*, 3581. [CrossRef] [PubMed]