

Energy-Saving Strategies for Enhancing Outdoor and Semi-Outdoor Thermal Comfort in Smart Cities: A Systematic Review

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INTRODUCTION & AIM

- Cities face growing thermal discomfort due to heat islands and climate change.
- Smart cities seek energy-efficient strategies to improve **outdoor and semi-outdoor** comfort.
- This systematic review (2020–2025) identifies, classifies, and evaluates **energy-saving interventions** for thermal comfort in urban areas.

METHOD

- **Databases:** Scopus & Web of Science
- **Years:** 2020–2025
- **Keywords:** “thermal comfort”, “smart cities”, “energy-saving”, “outdoor”, “AI”, etc.
- **Inclusion Criteria:**
 - Peer-reviewed journal/conference articles
 - English
 - Focus on smart city energy-saving strategies and thermal comfort
- **Categorisation:**
 - Passive Solutions (e.g., vegetation, cool surfaces)
 - Smart Materials (e.g., thermochromic coatings)
 - AI-driven HVAC
 - Sensor-based human-centric IoT
 - Energy Management Systems (EMS)

RESULTS & DISCUSSION

Two main performance clusters emerged:

passive interventions and **technology-enabled systems**.

Passive solutions (vegetation, cool materials, phase-change materials) achieved the **strongest outdoor cooling**, lowering MRT by **up to 4 °C** and surface temperatures by **up to 20 °C**.

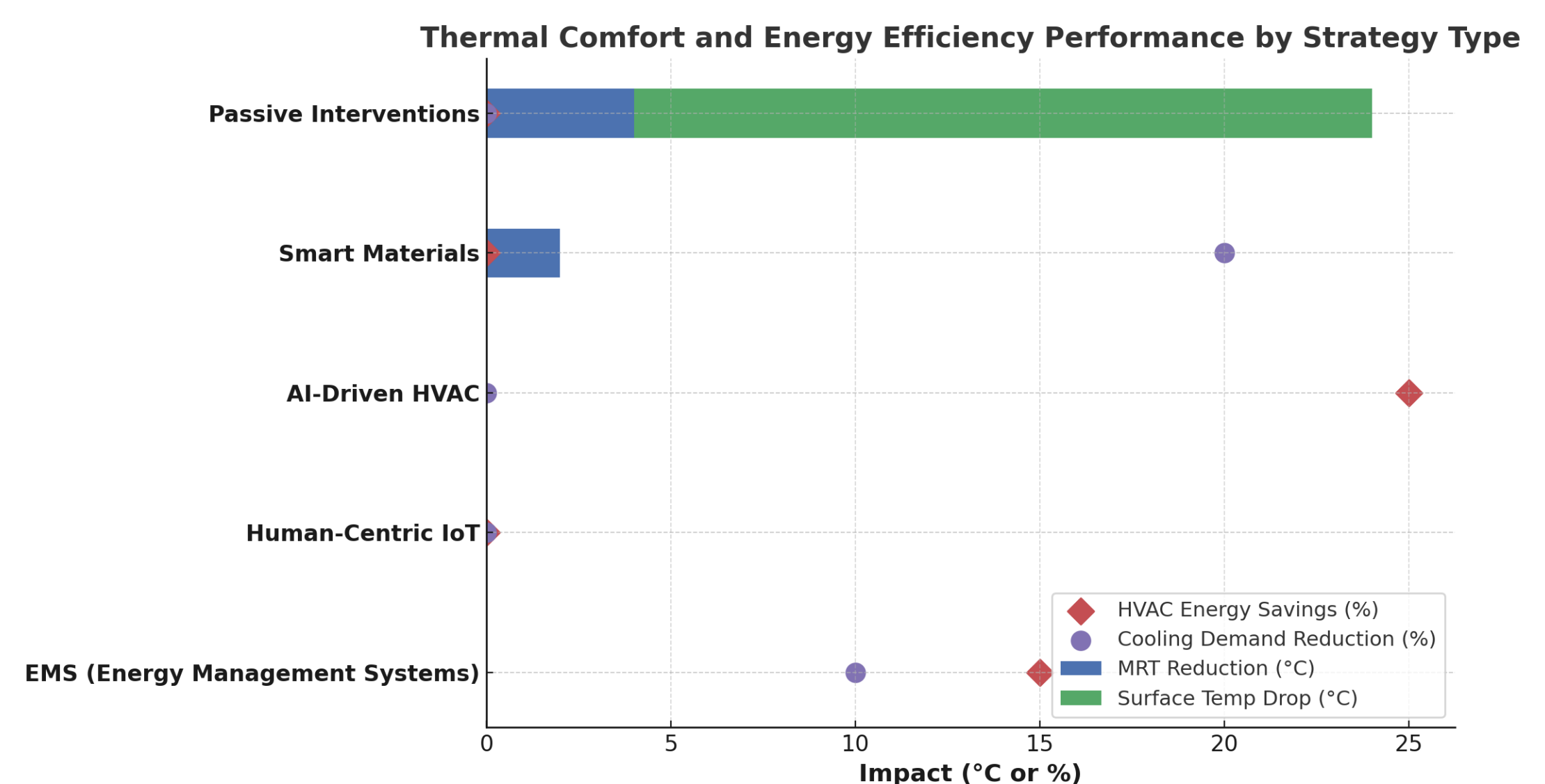


Figure 1. Combined performance Graph

Smart approaches—thermochromic materials, AI-driven HVAC, and EMS—reduced cooling demand by 10–25 % and improved HVAC energy efficiency by 20–30 %.

Geographic Trends

Most studies originated from China, USA, Spain, India, and the Netherlands, with limited research in the MENA and Sub-Saharan Africa regions.

Few works integrate thermal perception data or address equity in comfort distribution.

CONCLUSION

- Passive strategies offer the best outdoor cooling.
- Smart systems improve energy efficiency.

FUTURE WORK / REFERENCES

- Include user perception and real-world testing.
- Focus on underrepresented regions.