Cool cities, local contexts: A typology of urban heat interventions across disciplines

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The confluence of climate change, urbanization and the urban heat island effect make increasing temperatures a significant risk for urban populations. To address heating, decision-makers have many options with unique risks, benefits and efficacies - which has the potential to make nuanced decisions needlessly convoluted. Ultimately, there is no "silver bullet" solution to addressing urban heat, and decisions should be led by local health, energy and environmental needs. This study seeeks to support decision-making by organising interventions into a typology and comparing across these categories consistently to the extent possible.

Goals

- Collect interventions for increasing cooling demand from a broad range of disciplines
- Categorize interventions into groups which bring order to decision-making based on approach and priority goals

Methods

- Snowball, umbrella literature review, beginning with academic literature across key research areas, including:
  - Microclimateology
  - Buildings decarbonisation
  - Energy systems
  - Behavioral science
- Categorization based on
  - The mechanism by which temperatures are addressed
  - At what scale the intervention has an impact

	Reducing external temperatures	Building envelope	Behavior change	Decarbonizing the energy system
	Urban greening and "blue"ing, albedo management	*Reduce heat transfer, mechanical cooling*	*Demand-side flexibility, adaptive behavior*	*Decarbonization, S/D matching, Building management*
System	Ecological and Environmental	Infrastructual	Social	Energy
Scale	Street/Neighborhood	Building	Individual	Grid/Region/Nation
Actor	Local government, Developers, Home Owners Associations	Local Government, Property Managers, Private Owners	Individuals	Generators, Utility Companies, Regulatory Bodies
Interventions	• Green roofs and walls • White/"Cool" roofs • Pools and ponds • Lighter pavement coating	• Window glazing • Insulation • Shading • Air conditioning	• Inc. temp. set point • Pre-cooling • Closing windows (day) • Removing layers	• Increase low-carbon power • Reduce curtailment • Grid reinforcement • Microgrids

Major conclusions

- There is a lack of consistency in benefits of implementing interventions, which leads to difficulty in direct comparison, particularly across disciplines
- Different categories have different magnitudes of benefit across different goals
- Some interventions bring immediate relief, while others are indirect but still crucial for long-term success
- Interventions are complementary, and should ideally be implemented in tandem

Future research

- Tangible savings of reducing external temperatures and building envelope based on housing characteristics
- Impact by intervention across climate zones
- Implementation and monitoring of external temperature reduction interventions

Reducing external temperatures

Key goals addressed: Health, equity

Benefits:
- (Mental) well-being
- Social cohesion
- Peak temperature reduction

Risks:
- Low efficacy (abs. temperature reduction)
- Ongoing maintenance
- Ease of implementation

Key references:

Santamouris, M. et al. Passive and active cooling for the outdoor built environment – Analysis and assessment of the cooling potential of mitigation technologies using performance data from 220 large scale projects. Solar Energy 154, 14–33 (2017).
Santamouris, M. Cooling the cities - A review of reflective and green roof mitigation technologies to fight heat island and improve comfort in urban environments. Solar Energy 103, 682–703 (2014).

Building envelope

Key goals addressed: GHGs, E demand, equity

Benefits:
- Significant efficacy
- Energy bills savings (year-round)
- Increased energy efficiency

Risks:
- Bespoke feasibility
- Ease of implementation
- Upfront costs

Key references:

Tejero-Gonzalez, A., Andres-Chicote, M., Garcia-Ibanez, P., Velasco-Gomez, E. & Rey-Martinez, F. J. Assessing the applicability of passive cooling and heating techniques through climate factors: An overview. Renewable and Sustainable Energy Reviews 727–742 (2016) doi:10.1016/j.rser.2016.06.077.
Bhamare, D. K., Rathod, M. K. & Banerjee, J. Passive cooling techniques for building and their applicability in different climatic zones - The state of art. Energy Build 467–490 (2019) doi:10.1016/j.enbuild.2019.06.2023.

Behavior Change

Key goals addressed: Health, E demand, GHGs

Benefits:
- Energy bills savings
- Reduced curtailment

Risks:
- Social acceptability
- Risk of rebound effect
- Inconsistent over time

Key references:

Bae, C., Lee, H. & Chun, C. Beyond the thermostat: A behavioural study of residential cooling practices. Build Environ (2025) doi:j.buildenv.2025.113250.
Naderi, S., Pgnatta, G., Heslop, S., MacGill, I. & Chen, D. Demand response via pre-cooling and solar pre-cooling: A review. (2022) doi:10.1016/j.enbuild.2022.112340.
Hafner, R. J., Elmes, D. & Read, D. Promoting behavioural change to reduce thermal energy demand in households: A review. Renewable and Sustainable Energy Reviews 205–214 (2019) doi:10.1016/j.rser.2018.12.004.

Decarbonizing the energy system

Key goals addressed: GHGs, E demand

Benefits:
- Weakens warming/energy use feedback loop
- Reduces long-term heat burden
- Increases positive long-term health outcomes

Risks:
- Regulatory delay
- Social acceptability
- Indirect impact

Key references:

IPCC WGIII. Climate Change 2022: Mitigation of Climate Change. (2022) doi:10.1017/9781009157926.001.
Johnson, N., Gross, R. & Staffell, I. Stabalisation wedges: measuring progress towards transforming the global energy and land use systems. Environmental Research Letters (2021) doi:10.1088/1748-9326/abec06.