

# ASSESSING THE INDOOR THERMAL AUTONOMY AND ENERGY EFFICIENCY OF A SCHOOL IN MONTREAL HAVING A REFLECTIVE BUILDING ENVELOPE: HISTORICAL AND FUTURE CLIMATE PERSPECTIVES

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# ABOUT US



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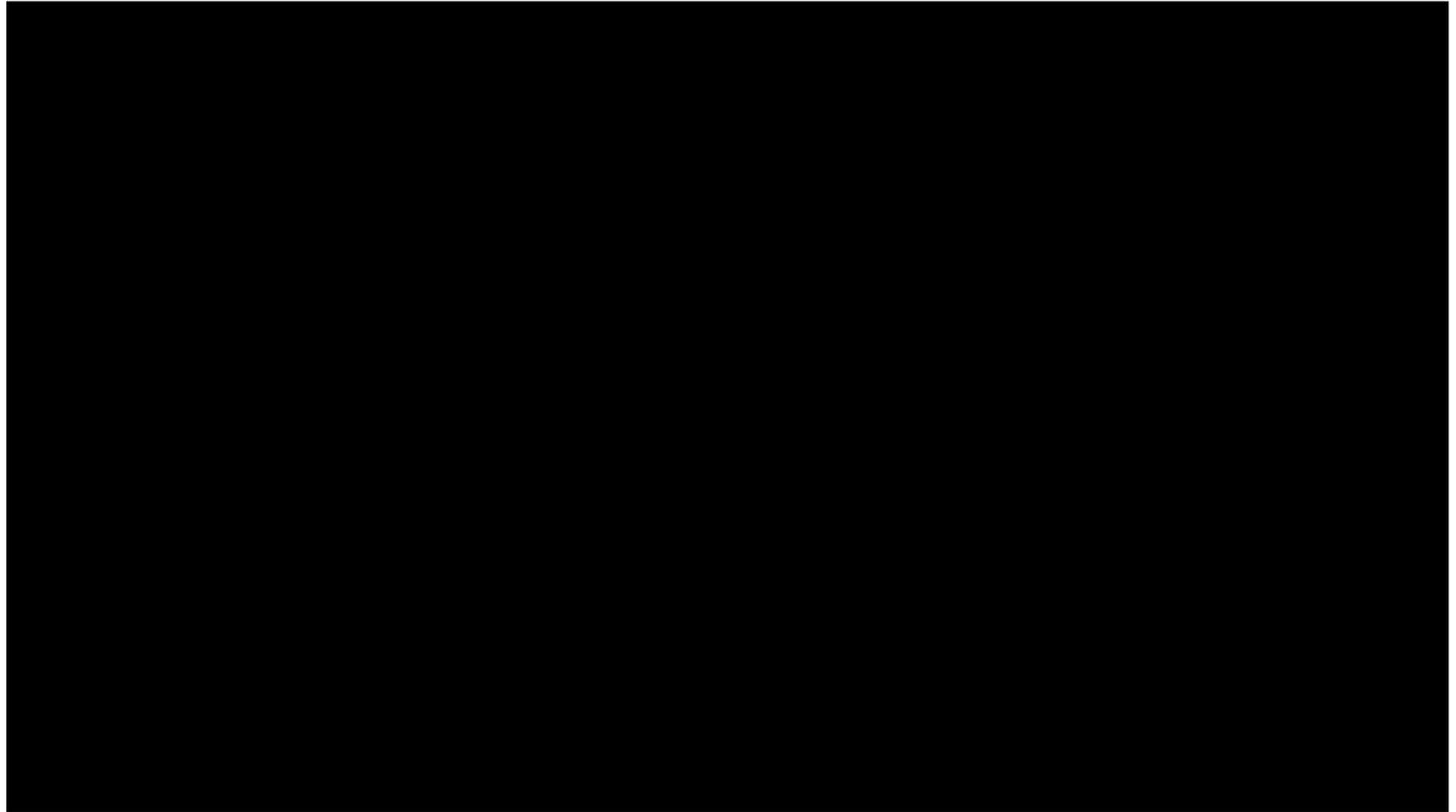


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# Climate Change

Climate change and rapid urbanization increase the need for sustainable, resilient building practices.

This study aligns with UN Sustainable Development Goal (SDG) 13, and Supports Canada's 2030 Emissions Reduction Plan, targeting a 40–45% GHG reduction by 2030 and net-zero by 2050.

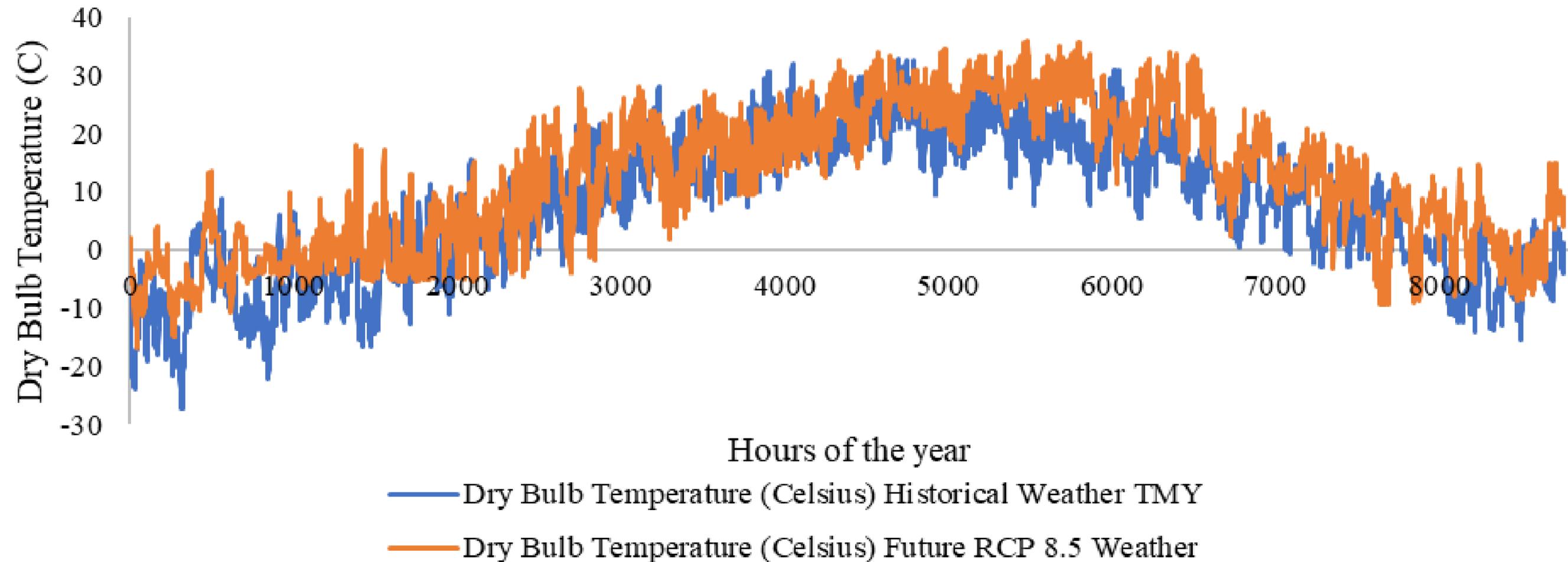


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## Research Focus

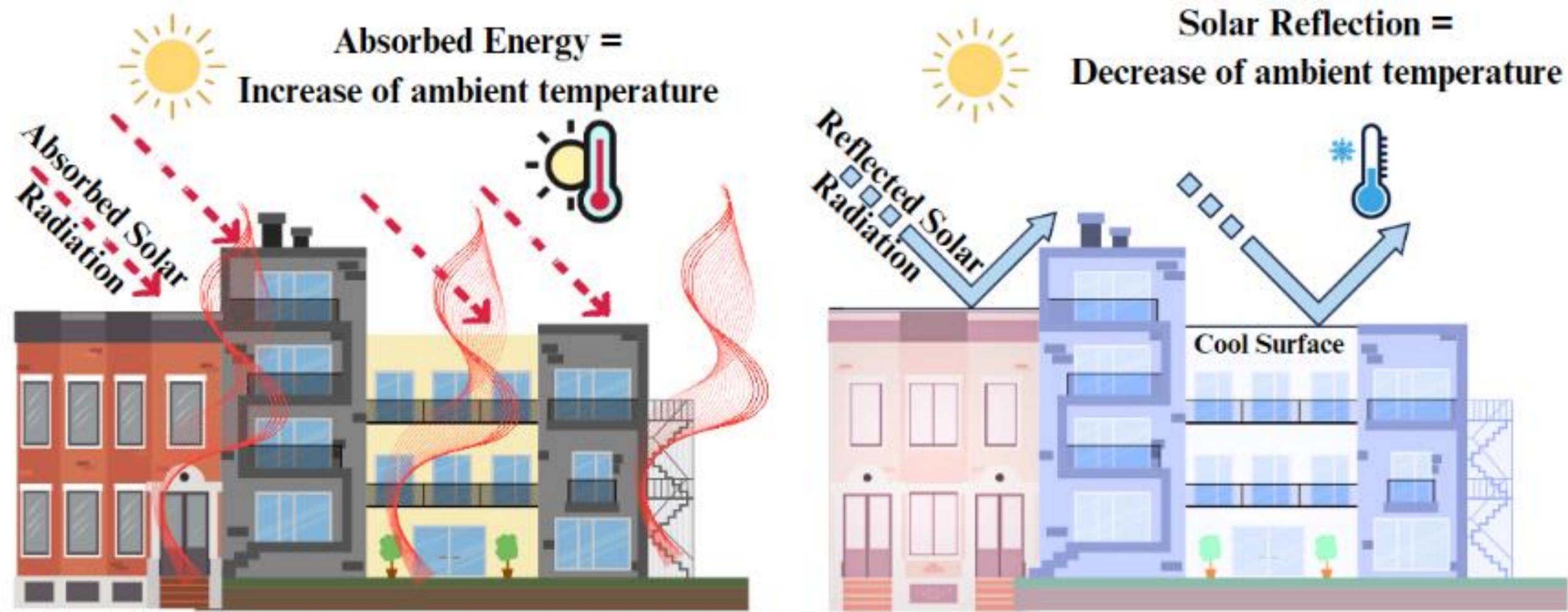
Examines reflective materials integrated into building envelopes. Aims to improve energy efficiency, thermal comfort, and climate resilience in urban settings.

# FUTURE CLIMATE TREND IN MONTREAL



Study uses climate files from the National Research Council of Canada (NRC). Includes both historical weather data (*Gaur & Lacasse, 2022*) and projected future weather scenarios (*Lu et al., 2024*).

# Reflective Materials



Increasing Solar Reflectivity of Building Envelope Materials to Mitigate Urban Heat Islands: State-of-the-Art Review, Ziaemehr et al. 2023.

# Reflective Materials

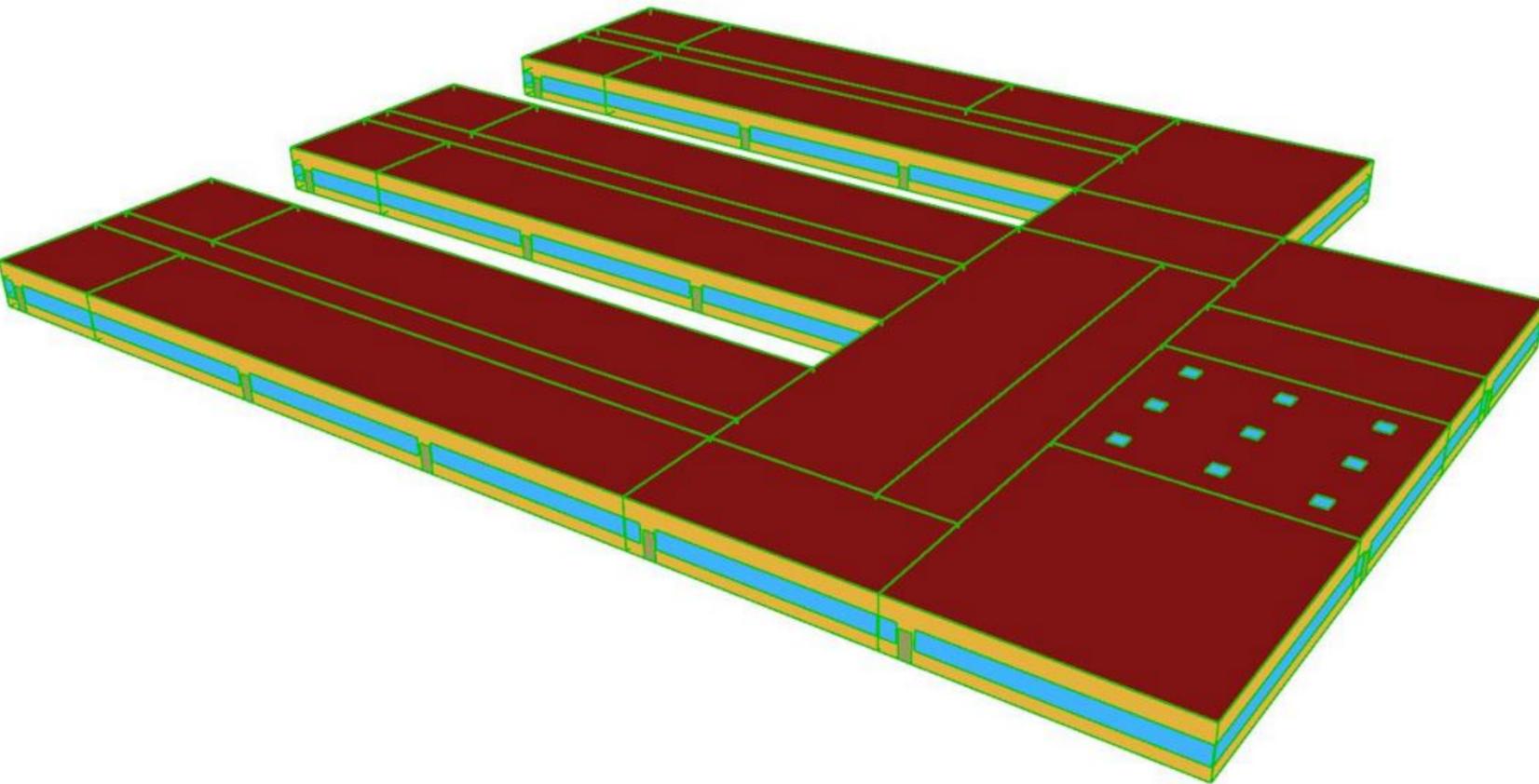


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# Methodology

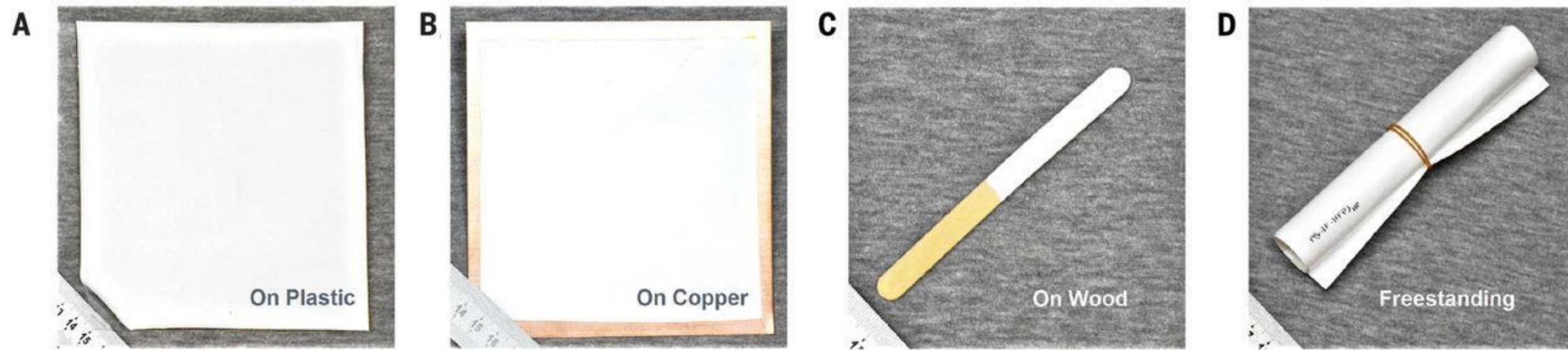


Baseline data was based on pre-1980 buildings from the CBECS database (Winiarski et al. 2006).

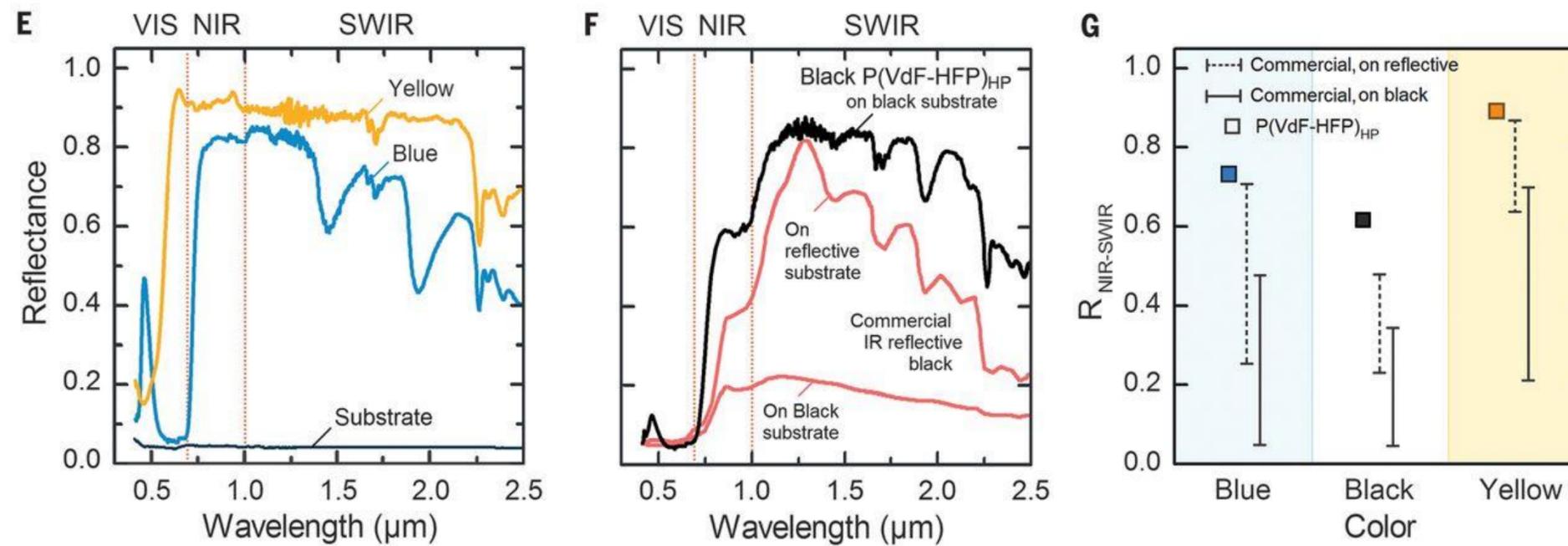
No.	Code	Year	Zone 6		Description
			4000<Heating Degree Days (HDD) <5000		
			Montreal (HDD=4200)		
			Minimum RSI (m <sup>2</sup> K/W)		
			Wall	Roof	
1	NBC (8 <sup>th</sup> Edition)	1980	1.73	1.71	By interpolation based on HDD values for different climate zones - ACNBC Residential Standards 1977
2	NBC (15 <sup>th</sup> Edition)	2020	3.08	4.67	Buildings without Heat-Recovery Ventilator

Occupancy	Lighting	Appliance and plug load	Infiltration	Set point (Celsius)	
				Heating	Cooling
People/m <sup>2</sup>	W/m <sup>2</sup>	W/m <sup>2</sup>	m <sup>3</sup> /s-m <sup>2</sup>		
0.215	7.2	16.5	0.000227	21	24

# Material Properties

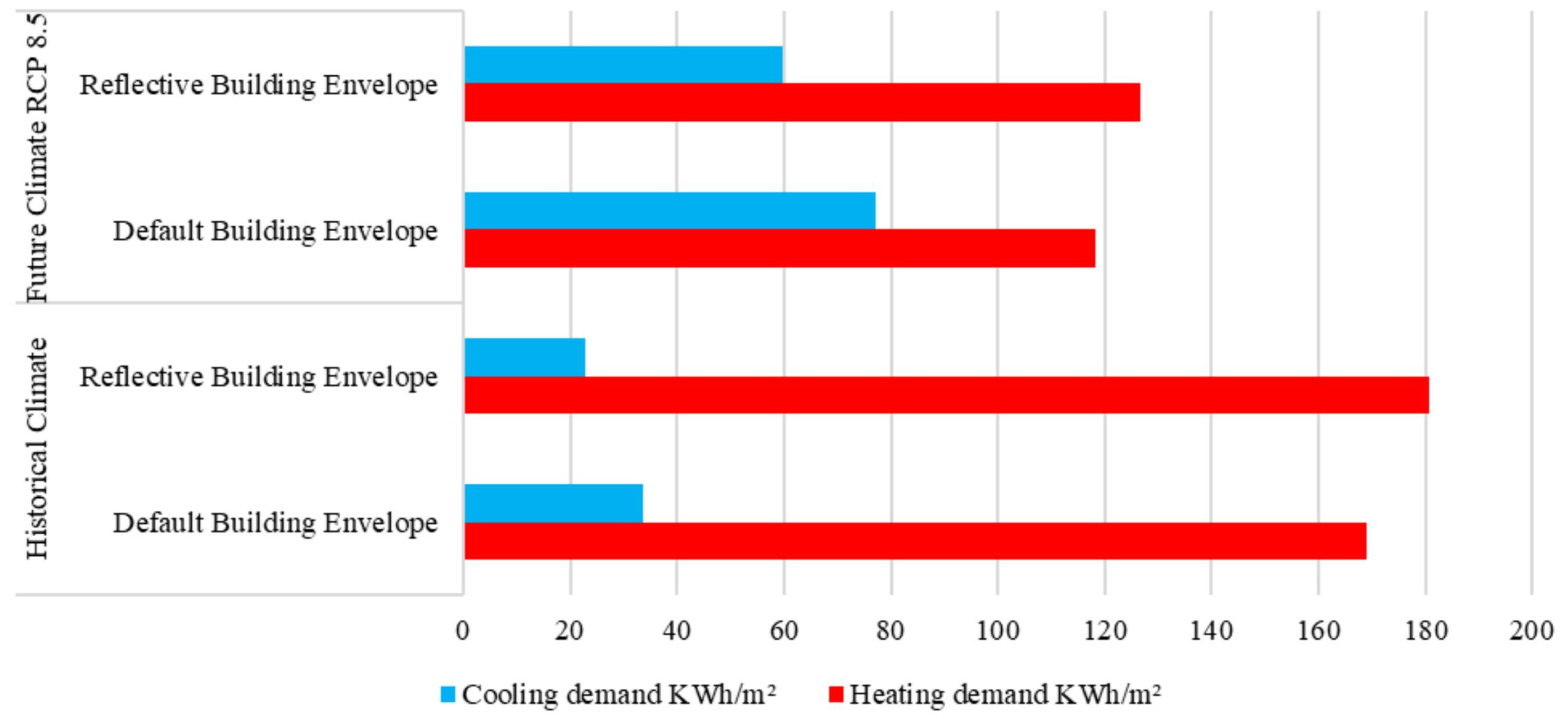


Initial Solar Properties		Enhanced Solar Properties	
Roof	Wall	Roof	Wall
$\beta_{\text{solar}} = 0.3$	$\beta_{\text{solar}} = 0.3$	$\beta_{\text{solar}} = 0.98$	$\beta_{\text{solar}} = 0.72$
$\epsilon = 0.9$	$\epsilon = 0.9$	$\epsilon = 0.9$	$\beta_{\text{visible}} = 0.59, \epsilon = 0.9$



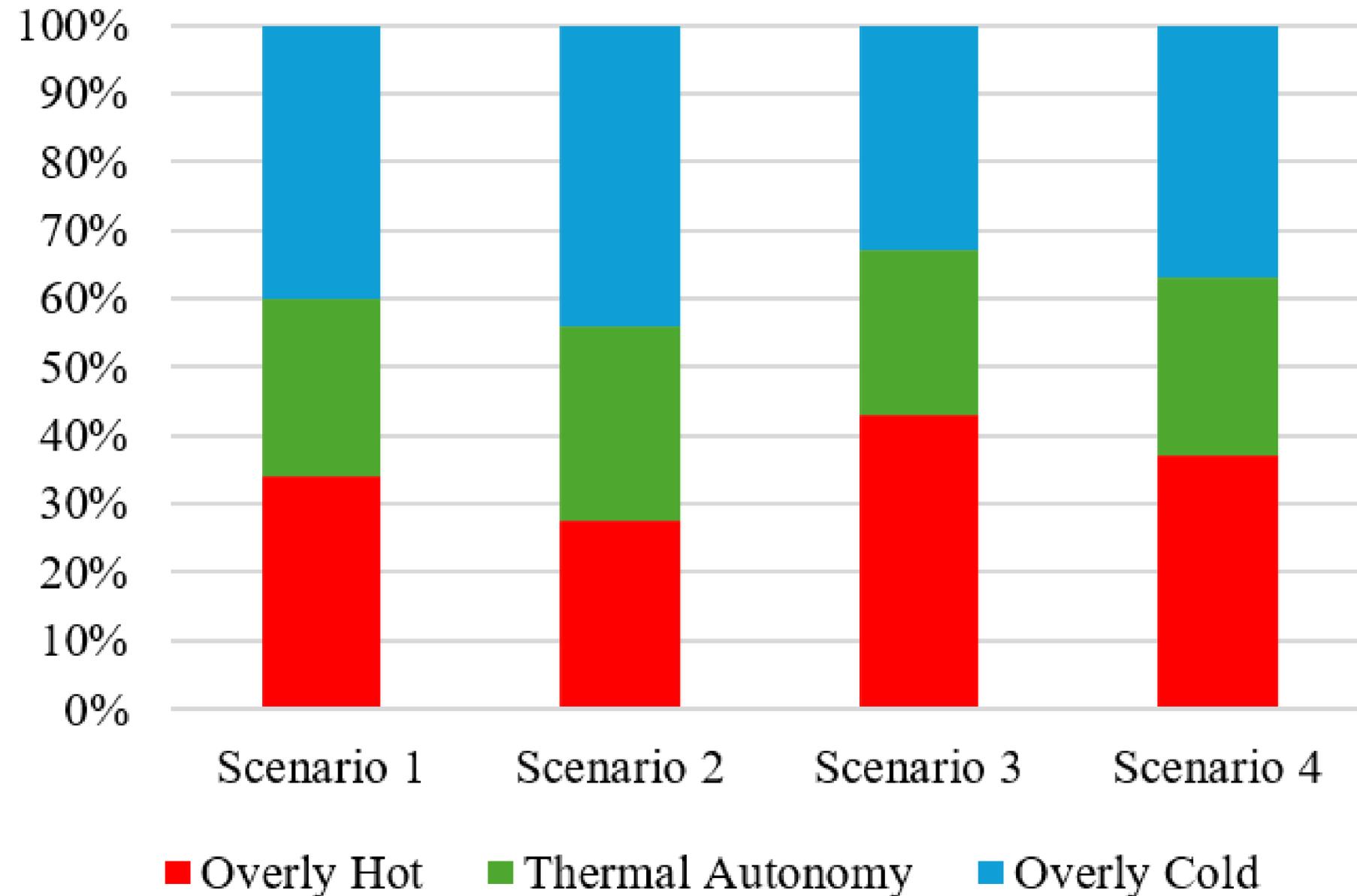
Mandal, J., Fu, Y., Overvig, A.C., Jia, M., Sun, K., Shi, N.N., Zhou, H., Xiao, X., Yu, N., and Yang, Y., 2018a. Hierarchically porous polymer coatings for highly efficient passive daytime radiative cooling. *Science*, 362 (6412), 315–319.

# Energy Results

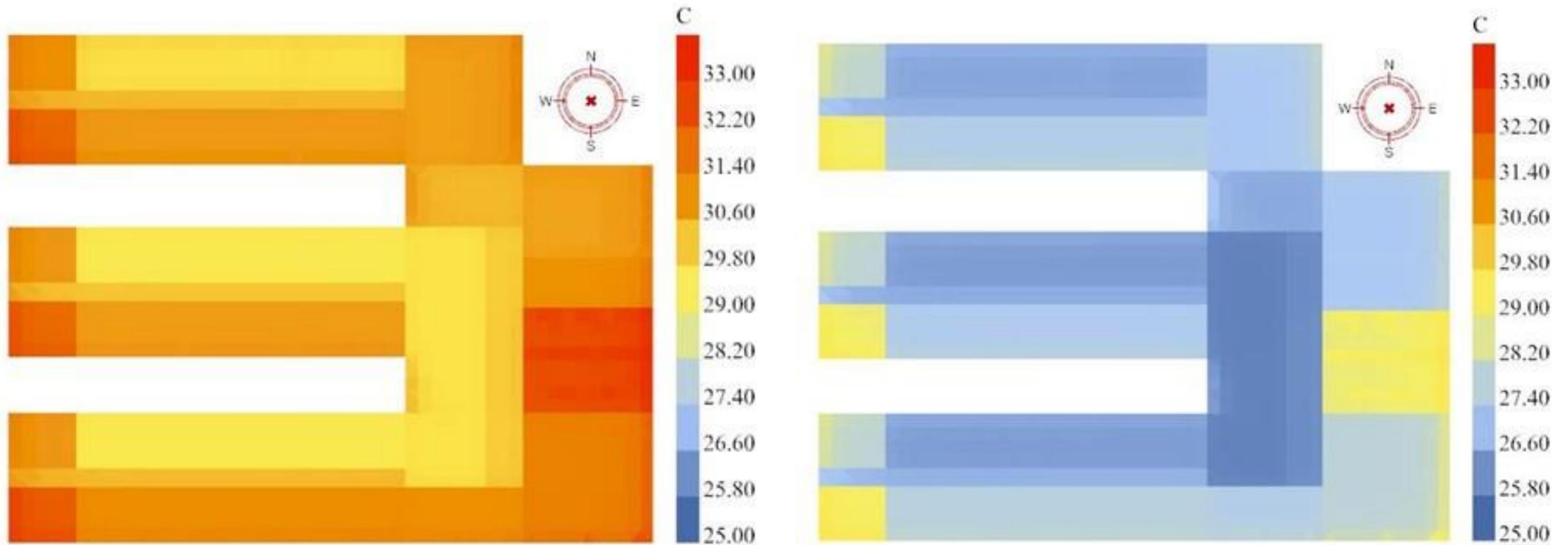


# Indoor Thermal Autonomy (ITA)

- **Scenario 1:** Building with default reflectivity (historical climate).
- **Scenario 2:** Building with a reflective envelope (historical climate).
- **Scenario 3:** Building with default reflectivity (future climate).
- **Scenario 4:** Building with a reflective coating (future climate).



# Average operative temperature



The average operative temperature during an extreme hot week (July 13–19) for a 1980 school with default (Left) vs. reflective envelope (Right) under historical weather.

# Conclusions

- Reflective envelopes increase heating demand, especially in colder climates, but this effect is smaller under future warmer conditions.
- They reduce cooling demand and are more effective in future climates, improving total energy efficiency by up to 4.6%.
- Reflective materials enhance indoor comfort (ITA) by increasing hours within the 18–25°C range.
- They reduce overheating risks, lowering peak indoor temperatures by up to 3.35°C.
- A trade-off exists: reflective surfaces also increase overly cold hours, potentially raising heating needs.
- Best used as a climate adaptation strategy in warmer regions; in cold climates, must be paired with good insulation.
- Older, under-insulated buildings show more impact; newer buildings may experience less dramatic effects.
- Balanced design is key to optimizing comfort and energy use year-round.



# THANK YOU

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