What if new materials provided sustainable cooling solutions in a warming world?

Cool Materials

Within Reach Transitional Visionary

Advanced cooling systems with nanoengineered materials dynamically adapt to temperature changes, reducing air-conditioning needs and enhancing efficiency of cooling solutions.



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UNCERTAINTIES

Technology, Systems

MEGATREND (Most significant)

Materials Revolution

TRENDS

ESG & Beyond GDP Mobilising Innovation Net Zero New Materials Urban Design

TECHNOLOGIES

Internet of Things (IoT) Nanotechnology

SECTORS IMPACTED

Data Science, AI & Machine Learning Energy, Oil & Gas, & Renewables Infrastructure & Construction Manufacturing Materials & Biotechnology Real Estate Utilities

KEYWORDS

Air Conditioning Climate Policies Heatwaves Hydrofluorocarbon Refrigerants Nanoengineered Insulation

The Global 50 (2025)



By 2030,

500 million

people, mainly in South Asia and the Middle East, **will face extreme heat for over 30 days annually, quadrupling current exposure**



By 2050, two-thirds of households

could own **air conditioners**

WHY IT MATTERS TODAY

Heatwaves have intensified since the 1950s and, by 2030, 500 million people, mainly in South Asia and the Middle East, will face extreme heat for over 30 days annually, quadrupling current exposure.⁹⁶⁵

Global air conditioner sales continue to increase with rising temperatures and incomes. Use of air conditioning in households has tripled since 1990, exceeding 100 million units annually.⁹⁶⁶ In 2016, 42 million units were sold in China, the most for any country,⁹⁶⁷ and by the end of 2016, there were 1.6 billion air conditioners in use worldwide, including 570 million in China, 375 million in the United States, 50 million in the Middle East, and nearly 30 million in India.⁹⁶⁸ By 2050, two-thirds of households could own air conditioners.⁹⁶⁹

International non-governmental organisations and governments around the world are looking at future climate scenarios to inform their cooling policies.⁹⁷⁰ Many are testing approaches such as urban greenery, irrigation, and geoengineering.^{971,972} Indoor cooling and heating using 30% of global energy⁹⁷³ and cooling responsible for 4% of global greenhouse gas emissions.⁹⁷⁴ Current refrigerants, such as hydrofluorocarbons (HFCs), contribute significantly to climate change.⁹⁷⁵ Nature-based and alternative solutions will be key.⁹⁷⁶

There is unequal access to cooling globally, with impacts on health. Only 15% of households in the hottest regions have air conditioning, with adoption as low as 5% in sub-Saharan Africa and 24% in India, compared with over 85% in high-income countries such as Japan and the United States.⁹⁷⁷ Heat-related deaths among seniors have risen by 61% over two decades, averaging 300,000 annually.⁹⁷⁸



BENEFITS

Accessible cooling; reduced energy consumption and carbon emissions; decrease in health risks; heating and cooling cost savings.



RISKS

High initial implementation costs; unforeseen health impacts from exposure to nanomaterials (e.g. nanoparticles in the air); long-term durability.

THE OPPORTUNITY

Cooling solutions evolve into comprehensive systems with advanced materials at their core. Nanoengineered insulation eliminates the need for air conditioners in regions with moderate climates and significantly enhances air-conditioning efficiency in warmer regions. These innovative materials dynamically adapt to temperature changes. Combined with innovations in ventilation,⁹⁷⁹ radiant cooling,⁹⁸⁰ and cooling roof technologies,⁹⁸¹ they enable the next generation of green air conditioners.⁹⁸² These systems integrate solar photovoltaics, efficient cooling, advanced coolants, temperature–sensing technologies, and next-generation batteries.

Using advanced machine intelligence, the structure, composition and arrangement of different nanoengineered insulation layers⁹⁸³ are optimised for each type of climate. These multilayered nanomaterials incorporate phase-changing materials.⁹⁸⁴

Combined with innovations in ventilation, radiant cooling, and cooling roof technologies, **advanced materials** enable the

next generation of green air conditioners



