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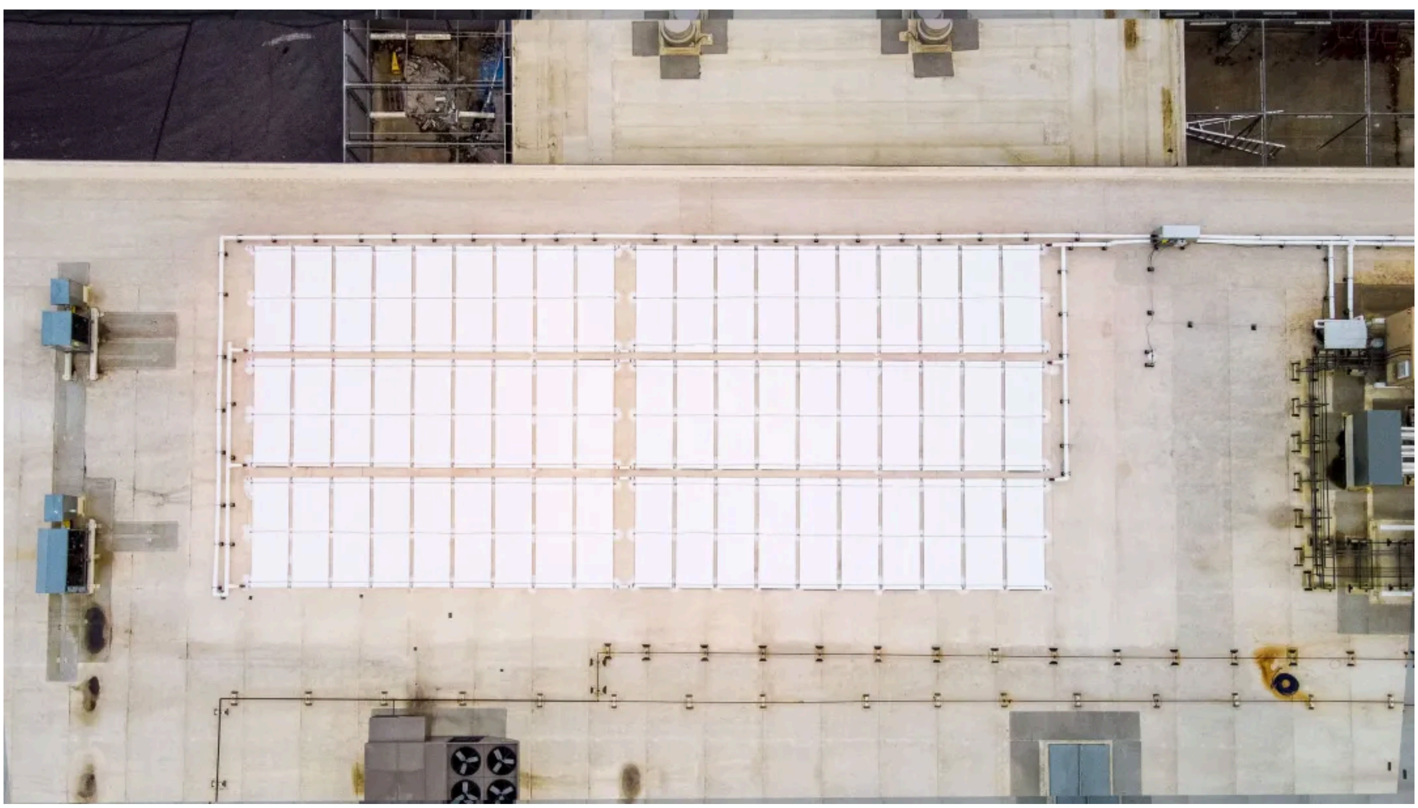
CLIMATE CHANGE AND ENERGY

The paints, coatings, and chemicals making the world a cooler place

Radiative cooling technologies scatter heat and light into space, which could cut air-conditioning demand and keep people safe in heat waves.

By Becky Ferreira

December 26, 2025



SkyCool Systems applies a photonic film to panels that deflect heat at infrared wavelengths.

COURTESY OF SKYCOOL SYSTEMS

Europe, and the Middle East. Global warming means more people need air-conditioning, which requires more power and strains grids. But a millennia-old idea (plus 21st-century tech) might offer an answer: radiative cooling. Paints, coatings, and textiles can scatter sunlight and dissipate heat—no additional energy required.

"Radiative cooling is universal—it exists everywhere in our daily life," says Qiaoqiang Gan, a professor of materials science and applied physics at King Abdullah University of Science and Technology in Saudi Arabia. Pretty much any object will absorb heat from the sun during the day and radiate some of it back at night. It's why cars parked outside overnight are often covered with condensation, Gan says—their metal roofs dissipate heat into the sky, cooling the surfaces below the ambient air temperature. That's how you get dew.

Humans have harnessed this basic natural process for thousands of years. Desert peoples in Iran, North Africa, and India manufactured ice by leaving pools of water exposed to clear desert skies overnight, when radiative cooling happens naturally; other cultures constructed "cool roofs" capped with reflective materials that scattered sunlight and lowered interior temperatures. "People have taken advantage of this effect, either knowingly or unknowingly, for a very long time," says Aaswath Raman, a materials scientist at UCLA and cofounder of the radiativecooling startup SkyCool Systems.

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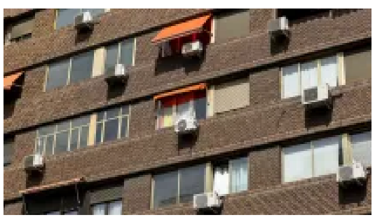


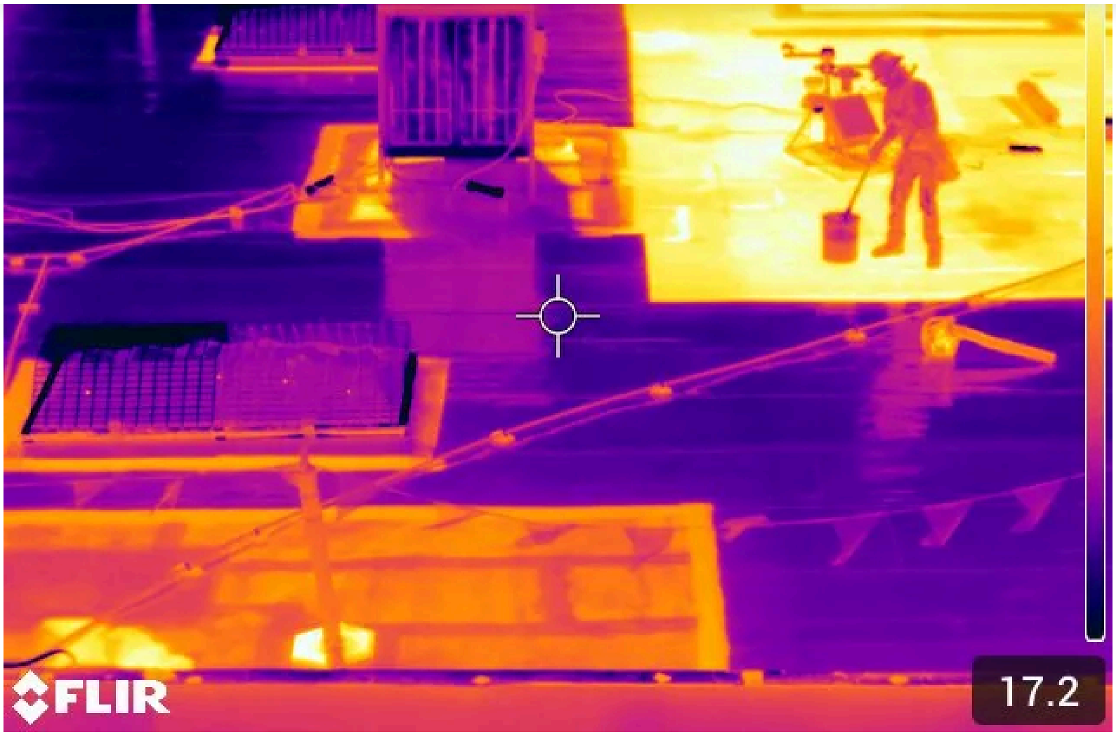
In defense of air-conditioning

Modern approaches, as demonstrated everywhere from California supermarket rooftops to Japan's Expo 2025 pavilion, go even further. Normally, if the sun is up and pumping in heat, surfaces can't get cooler than the ambient temperature. But back in 2014, Raman and his colleagues achieved radiative cooling in the daytime. They customized photonic films to absorb and then radiate heat at infrared wavelengths between eight and 13 micrometers—a range of electromagnetic wavelengths called an "atmospheric window," because that radiation escapes to space rather than getting absorbed. Those films could dissipate heat even under full sun, cooling the inside of a building to 9 °F below ambient temperatures, with no AC or energy source required.

That was proof of concept; today, Raman says, the industry has mostly shifted away from advanced photonics that use the atmospheric-window effect to simpler sunlight-scattering materials. Ceramic cool roofs, nanostructure coatings, and reflective polymers all offer the possibility of diverting more sunlight across all wavelengths, and they're more durable and scalable.

Now the race is on. Startups such as SkyCool, Planck Energies, Spacecool, and i2Cool are competing to commercially manufacture and sell coatings that reflect at least 94% of sunlight in most climates, and above 97% in humid tropical ones. Pilot projects have already provided significant cooling to residential buildings, reducing AC energy needs by 15% to 20% in some cases.

This idea could go way beyond reflective rooftops and roads. Researchers are developing reflective textiles that can be worn by people most at risk of heat exposure. "This is personal thermal management," says Gan. "We can realize passive cooling in T-shirts, sportswear, and garments."



A thermal image captured during a SkyCool installation shows treated areas (white, yellow) that are roughly 35 ºC cooler than the surrounding rooftop.

COURTESY OF SKYCOOL SYSTEMS

Of course, these technologies and materials have limits. Like solar power grids, they're vulnerable to weather. Clouds prevent reflected sunlight from bouncing into space. Dust and air pollution dim materials' bright surfaces. Lots of coatings lose their reflectivity after a few years. And the cheapest and toughest materials used in radiative cooling tend to rely on Teflon and other fluoropolymers, "forever chemicals" that don't biodegrade, posing an environmental risk. "They are the best class of products that tend to survive outdoors," says Raman. "So for long-term scale-up, can you do it without materials like those fluoropolymers and still maintain the durability and hit this low cost point?"

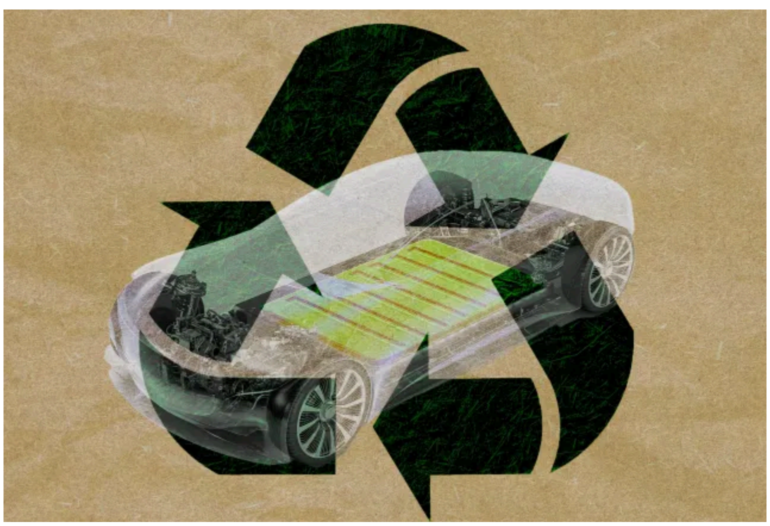
As with any other solution to the problems of climate change, one size won't fit all. "We cannot be overoptimistic and say that radiative cooling can address all our future needs," Gan says. "We still need more efficient active air-conditioning." A shiny roof isn't a panacea, but it's still pretty cool.

Becky Ferreira is a science reporter based in upstate New York and author of First Contact: The Story of Our Obsession with Aliens.

by Becky Ferreira

DEEP DIVE

CLIMATE CHANGE AND ENERGY



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