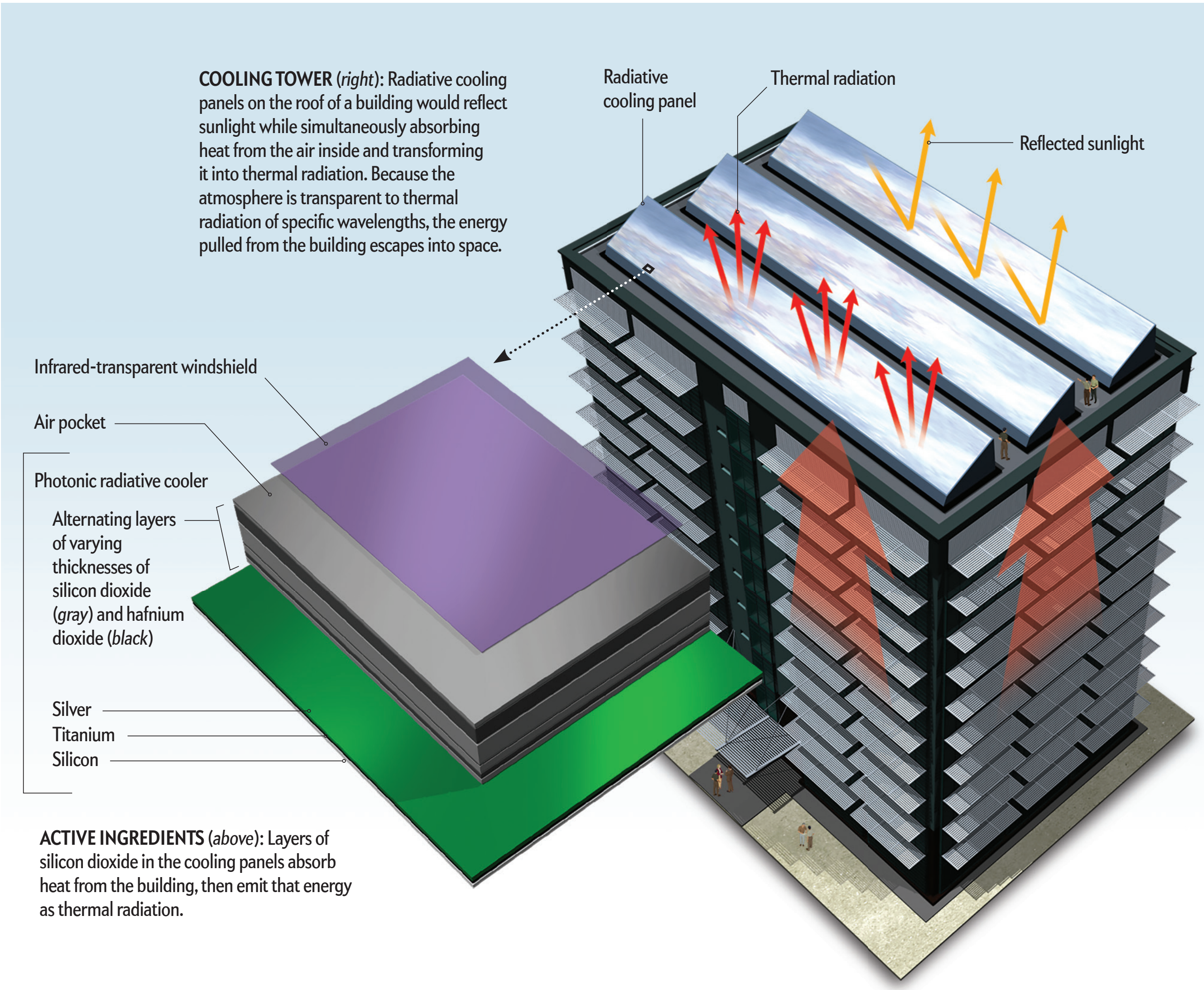

COOLING TOWER (*right*): Radiative cooling panels on the roof of a building would reflect sunlight while simultaneously absorbing heat from the air inside and transforming it into thermal radiation. Because the atmosphere is transparent to thermal radiation of specific wavelengths, the energy pulled from the building escapes into space.

ACTIVE INGREDIENTS (*above*): Layers of silicon dioxide in the cooling panels absorb heat from the building, then emit that energy as thermal radiation.

The Heat Vacuum

A multipurpose mirror sucks up heat and beams it into outer space

Air-conditioning accounts for nearly 15 percent of building energy use in the U.S. today. The number of days with record heat could soar in the coming decades. These two facts present a difficult problem: In a warming world, how can we cool our homes and workplaces while reducing energy use?

Researchers at Stanford University say part of the solution is a material that sucks heat from sun-drenched buildings and radiates it into outer space. The basic concept, known as radiative cooling, originated in the 1980s, when engineers found that certain types of painted-metal roofing pulled heat from buildings and radiated it in wavelengths that pass through the earth's atmosphere unimpeded. Radiative cooling never worked during the day, however, because no one had made a material that both radiates thermal energy and reflects sunlight. Reflection is critical: if a material absorbs sunlight, heat from the sun negates any cooling that thermal radiation might achieve.

To solve the problem, the Stanford team created what amounts to a very effective mirror. In trials on the roof of its lab, the material, made of layers of hafnium dioxide and silicon dioxide on a base of silver, titanium and silicon, reflected 97 percent of sunlight. The silicon dioxide atoms behave like tiny antennas, absorbing heat from the air on one side of the panel and emitting thermal radiation on the other. The material radiates primarily at wavelengths between eight and 13 nanometers. The earth's atmosphere is transparent to these wavelengths, so rather than warming the air around the building, the heat escapes to space. Even in direct sunlight, the group's 20-centimeter-diameter wafer is about five degrees Celsius cooler than the air.

Shanhui Fan, an electrical engineer at Stanford and senior author of a 2014 *Nature* paper describing the work, imagines panels of the material covering the roofs of buildings. With its roof continually expelling heat, a building's air-conditioning can relax and consume less energy. There could be other applications. Remove the mirror component and pair the material with solar cells, for example, and it could cool the cells while allowing light to reach them, making them more efficient. "It's very interesting to think about how one could tap into this enormous thermodynamic resource that the universe as a heat sink represents," Fan says. "We're really only at the very beginning of recognizing this underexplored renewable energy resource." —*R.N.*

Illustration by Don Foley