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Heat Pumps—the Well-Tempered Future of A/Cs

The world wants a billion new air conditioners? Greener tech will bring the cool

BY LUCAS LAURSEN 4 HOURS AGO

Heat pumps (this one by the startup Gradient Comfort) offer solutions to major sources of climate-forcing emissions. They consume less electricity, can be more economical to run, and work with lower-impact refrigerants. And they're ready to be scaled up for the next billion people seeking air-conditioning units installed in their homes. GRADIENT COMFORT

During heat waves in Phoenix, while some people fry eggs on sidewalks, Matt Heath, a heating, ventilation, and air-conditioning (HVAC) service manager at AC by J, is on the front line, helping maintain air conditioners in people's homes. Heath has great job security: Half of Phoenix residents are at risk of an emergency-room visit or worse if their electricity fails during a future heat wave, according to a recent study. Air-conditioning is what keeps people there comfortable—and alive—a growing fraction of the year. The extreme heat already kills hundreds of Phoenix-area residents every year, a number that went up by 25 percent from 2021 to 2022.

Phoenix is a harbinger of life in the many hot parts of the world that are getting richer, where people are demanding ever more air conditioners. This in turn exacerbates the extremes of climate change due to increased demand for fossil-fuel-intensive sources of electricity, as well as leakage of refrigerants, themselves noteworthy greenhouse gases. "Most of the growth of air-conditioning will be in other countries," says mechanical engineer Vince Romanin, cofounder and CEO of the San

Francisco–based Gradient Comfort, “and restricting access is not fair.” Instead, he and others are trying to invent new climate-control technology that doesn’t further increase the dangers facing the planet’s climate.

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The winners of the 2021 Global Cooling Prize—both heat pumps—reduce cooling’s climate impact by as much as 80 percent.

Ironically, the most promising way to improve air conditioners may be to focus on heating. While governments around the world have dangled greater efficiency as a way of mitigating air-conditioning’s climate impact, innovation in air-conditioning, narrowly defined, is incremental. “Within the HVAC world, innovations tend to be small and progressive: There’s not some silver bullet,” says Wade Conlan, an engineer in Maitland, Fla., and vice president of ASHRAE, a heating and air-conditioning standards-setting organization. Better air conditioners, in a technical sense, really affect only the last link in a long, climate-harming supply chain, whereas replacing residential furnaces stands to make a bigger impact. Their fate, in turn, is tied to air conditioners through their versatile cousins, heat pumps.

It may seem like the cool air coming from your home’s air conditioner is coming from just the other side of the unit. But to

conditioner is coming from just the other side of the unit. But to get the air conditioner’s compressor working in the first place, a faraway power plant had to produce a surge of electricity. If, like 60 percent of the U.S. grid, that plant used a CO_2-emitting source, then the local problem may be solved, but only at the expense of a more global threat. On longer time frames, the refrigerant in your air conditioner will leak into the atmosphere where it, too, will absorb sunlight, possibly even more than CO_2, and heat the planet long after the blades of your air conditioner’s fan have stopped spinning.

This year, the U.S. Department of Energy tightened efficiency testing standards for air conditioners for the first time since 2015. Air conditioning is a mature technology, whose first patents date to the early 1900s and whose residential use goes back 90 years. As a result, air-conditioner manufacturers are probably more interested in keeping up with global demand than in developing expensive, potentially disruptive climate-impact improvements.

Still, in the United States, cooling represented just 8 percent of residential energy demand, compared with (as of 2015 at least) 43 percent for heating. In other words, an incremental efficiency improvement in heating will have a much bigger overall impact on energy demand and therefore climate change. And anything—such as electrically powered heat pumps—that can shift heating away from natural-gas furnaces to cleaner sources of energy would also have a big climate impact, because 63 percent of

would also have a big climate impact, because 60 percent of American homes get their heat from natural gas.

In fact, both winners of the 2021 Global Cooling Prize, aimed at improving air conditioners, address heating, because they are both heat pumps. As the Cooling Prize's website notes, their award-winning heat pumps—made by Gree in Zhuhai, China, and Daikin and Nikken in Haryana, India, and Tokyo, respectively—reduce cooling's climate impact by as much as 80 percent compared with the impact of traditional air-conditioning.

If air-conditioning is going to be climate-friendlier, says Romanin, of Gradient Comfort, "it needs to be smart, talk to the grid, use better refrigerant, and be a heat pump."

What are the pros and cons of a heat pump?

Heat pumps offer ways of addressing all three of the major sources of building-related climate-forcing emissions, Romanin says: natural-gas leakage in gas-powered furnaces, refrigerant leakage in air conditioners, and electricity use. All three, he says, have combined to create a problem set and solution space much bigger than anything he could achieve by just building a conventional air conditioner that's some fraction of a percent more efficient than last year's model.

Heat pumps eliminate the first of those sources altogether—no natural gas needed—and offer pathways to reducing the other two sources of climate-forcing emissions. Heat pumps are also compatible with natural refrigerants with lower climate impacts. They can consume less electricity than conventional central air conditioners, and their heating modes can be more cost-effective than gas furnaces in some climate zones. Plus, heat pumps offer the possibility of emissions-free power, depending on the local electricity supply, because they are electric.

With all these advantages, it may seem difficult to understand why more builders haven't adopted heat pumps. The institutional inertia behind air-conditioning is considerable, and legal conservatism explains some of the reasons for the slow transition: An architect won't get sued for calling for industry-standard HVAC, but he might if a relatively new-on-the-market heat pump doesn't meet a building operator's needs. Another reason is a problem every renter in the world has faced: The person who pays the energy bills isn't the person who selects and installs the appliances. That might have been more relevant when heat pumps cost more than air conditioners, but at least according to some estimates, they are now approaching up-front price parity with central air-conditioning, and are cheaper to install than a comparable air conditioner–gas furnace combination.

In one scenario, a heat pump might cost US $4,200 to $7,600 in installation costs, compared with $3,800 to $7,500 for central air-conditioning only. However, the fairer comparison would be to both a central air conditioner and a gas furnace, which might total $5,000 to $12,000. Of course, these competing technologies have different operating costs that depend on changing regional electricity and natural-gas prices. In the United States, an additional economic incentive to switch to heat pumps has been added to the mix. The U.S. Inflation Reduction Act of 2022 offers subsidies of up to $8,000 to households meeting certain income requirements for installing heat pumps.

Heath says that most of the homeowners he helps with heat-pump installations or conversions tell him they have an aversion to installing a natural-gas line or prefer not to have a source of combustion running through their homes. In southern Arizona, where most people use the heat for only a couple of weeks a year, the conversion may not even require a subsidy to add up. “It’s not very often we get someone who wants to [install a heat pump] for climate reasons,” says Heath, the HVAC service manager, “It’s mostly economic.”

Indeed, Conlan, who lives in Florida, says he worked out that a heat pump would pay off while he lived in his house, and he has had one instead of an air conditioner for decades.

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In colder parts of the country, the heating component of heat pumps matters more, and heat pumps cannot produce as much heat as gas furnaces in the coldest climates.

But some models are starting to be competitive in even traditionally cold-weather climates, argue several climate-focused civil society organizations, including the Building Decarbonization Coalition. Governments should educate and encourage homeowners and building contractors to replace air conditioners and furnaces with heat pumps, the coalition argued in a June 2023 report. “Up north there is a tipping point that they’re trying to get to,” Conlan says.

Air conditioners, gas furnaces, and heat pumps are only part of the climate-control story: Cleaner electricity production, more efficient grids, and better-insulated buildings are probably lower-hanging fruit. “The better you insulate, the less heat you need in the first place,” Conlan says.

Yet for now, heat pumps have the attention of regulators, major industry players, and civil society groups. They also have the attention of HVAC specialists such as Heath. Heat pumps tend to run on lower power settings more of the time compared with air conditioners. Heath says that makes them ripe for other improvements. For example, the HVAC industry might be able to eliminate the huge surges of current that legacy air conditioners need when they’re turned on, improving the health of the grid

and creating the possibility to powering heat pumps from sources such as solar panels or even domestic battery storage. Heath says, “I keep thinking, ‘What else is there?’”