

Heat Pumps Outperform Boilers and Furnaces Even in the Cold

Some utilities and fossil-fuel interests like to say heat pumps don't work in the cold. A new study provides yet more evidence to debunk that misrepresentation.

Alison F. Takemura

Not only do heat pumps function in freezing temperatures — they work far more efficiently than fossil-fuel heating systems in the cold.

That's according to a team of researchers in Europe affiliated with the independent nonprofit Regulatory Assistance Project. They published a study in *Joule* this week that provides yet more evidence to debunk the myth that heat pumps can't handle cold climates.

Electric heat pumps both heat and cool indoor spaces by moving heat into or out of them as needed. And while global sales grew by 11 percent in 2022, according to the International Energy Agency, heat pumps still only account for about a tenth of the world's building heating. To achieve the Paris Agreement's target of net-zero emissions by 2050, heat pumps will need to replace far more fossil-fuel boilers and furnaces — including in places with frigid winters.

Extreme cold historically has been a barrier for the technology, with major utilities and fossil fuel interests asserting that heat pumps don't work below freezing and pointing to drops in efficiency as evidence. But as the new study and examples from places including Norway and Maine have shown, modern heat pumps are reliable and outperform fossil-fuel heating in the cold.

To find out how well air-source heat pumps work as temperatures plummet, the team analyzed data from seven field studies across three continents, drawing on observations of different heat-pump models from Canada, China, Germany, Switzerland, the United Kingdom and the U.S.

These studies reported on heat-pump performance in the depths of winter — January — using a metric called the "coefficient of performance." COP measures how much thermal energy you can get out of a heating system for every unit of energy you put in. Heating technologies that burn fossil fuels or use electric resistance convert one form of energy into another, so they hit a thermodynamic limit at 100 percent efficiency, or a COP of 1.

But heat pumps cleverly move heat around using refrigerant. They can routinely achieve COPs of 3 to 4, though higher values are possible, according to Duncan Gibb, senior advisor at the Regulatory Assistance Project and co-author of the new study. For instantaneous measurements (as opposed to those averaged out over a day), "I've seen some data where it gets up to 7."

Efficiency declines when temperatures drop, however, as the gap between outdoor and desired indoor temperature widens. (This is the major reason why geothermal heat pumps, which draw heat from the earth and are much more insulated from the temperature swings in the ambient air, are more efficient.)

Even though the COP of air-source heat pumps declines as temperatures fall, the team found that heat pumps



The outdoor unit of an air source heat pump operating in freezing conditions. (Wikipedia)

surpass fossil and electric-resistance systems in efficiency — including at temperatures that define, for many Europeans, "the coldest days of the year," Gibb said.

Ninety-five percent of European households dwell in countries where mean January temperatures are higher than -5°C (23°F), according to Gibb. In those conditions — and indeed even at lower temperatures — heat pumps still hum along with a COP of 2 to 3, as shown in the chart.

Specially designed cold-climate heat pumps can produce heat in even more extreme weather, the team found, although these results aren't shown in the chart above. Heat pumps tested in temperatures as low as -30°C (-22°F) in Finland ran with a COP of 1.5 or higher, Gibb said.

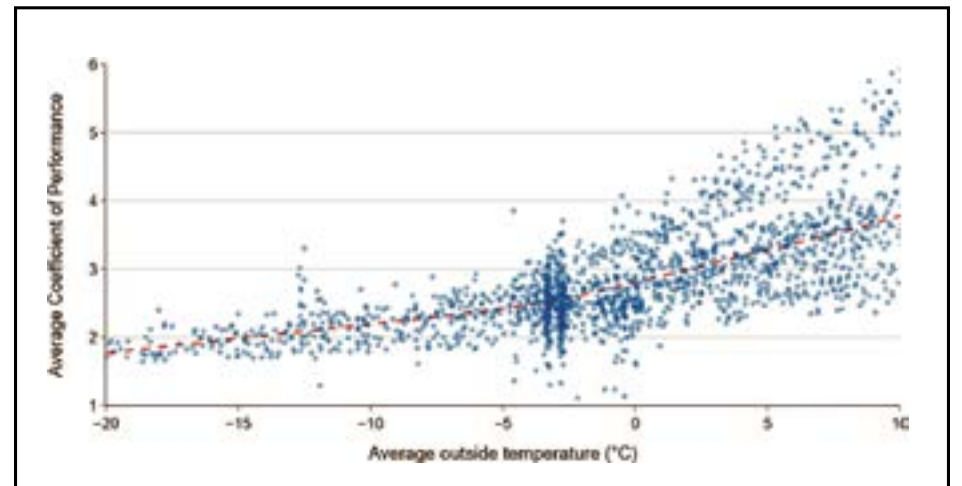
These observations are critical for countries figuring out how to get off fossil fuels, including France, Germany, the Netherlands and the U.K., Gibb noted. For Europe, "there are very few — if any — technical conditions where a heat pump is not suitable based on the climate."

That helps explain why heat pumps are taking off in some colder parts of the continent. The Scandinavian countries of Norway, Sweden and Finland have some of the frostiest winters in Europe, but they are also some of the most

enthusiastic heat-pump adopters. These countries experienced the highest per capita heat-pump sales in Europe in 2022, according to the authors.

As for the U.S., in 2022, Americans bought more heat pumps than gas furnaces. That includes success in Maine, which despite its bone-chilling winters has already blown past its goal to install 100,000 new heat pumps by 2025. In July, it upped its pledge to deploy 175,000 more by 2027. Customers in both Maine and Colorado have attested that their heat pumps kept them cozy

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Air-source heat pumps keep churning out heat in cold temperatures. Each dot is either a heat pump's instantaneously measured COP at a specific temperature or averaged across a day's range of COP and temperature values. Data is from seven field studies. (*Joule*)

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THE NEW CIVILIAN CLIMATE CORPS FOR JOBS AND JUSTICE



John Bos

America is facing an environmental crisis that is taking thousands of lives, costing us tens of billions a year, and causing tens of millions of people to attempt to migrate to countries where they believe they can survive.

We are not being helped by the fossil fuel industries whose bottom line and shareholder dividends take precedence over what they might be able to do to help avoid the planet's diminishing capacity to support millions of people, especially in the global south.

"Many of the largest companies have engaged in massive fraud," said former U.S. Vice President Al Gore in a harsh rebuke of the fossil fuel industry at the *New York Times'* Climate Forward event on September 21. Gore, who won the Nobel Peace Prize in 2007, criticized the industry for using their influence to lobby against effective climate action. "The fossil fuel companies, given their record today, are far more effective at capturing politicians than they are at capturing emissions," he said.

"I was one of many who felt for a long time that the fossil fuel companies, or at least many of them, were sincere in saying that they wanted to be a meaningful part of bringing solutions to this crisis," Gore said, as *The Independent* reported. "But I think that it's now clear they are not. Fossil fuel industry speaks with forked tongue."

While he acknowledged that it was not fair to expect the industry to solve a crisis its business model encouraged it to

perpetuate, "it's more than fair to ask them to get out of the way and stop blocking the efforts of everybody else to solve this crisis," he said. "I think it's time to call them out."

The last time our country faced an environmental disaster of similar severity, President Franklin D. Roosevelt stepped up and dealt with it. Now the Biden administration is doing the same. On September 20 President Biden rolled out a new American Climate Corps.

In 1933, America was both in the depths of the Great Depression and facing an environmental disaster of national proportions. Sweeping from Texas to Nebraska, the Dust Bowl lifted 1.2 billion tons of soil from over 100 million acres, blowing it as far east as New York City, where it browned out the skies for weeks. The Dust Bowl killed around 7,000 people and left at least 2 million homeless.

The storms also had a cascade effect on U.S. agriculture. Wheat production fell by 36% and maize production plummeted by 48% during those years. On a single day, "Black Sunday" April 14, 1935, an estimated three million tons of topsoil were lost from the Great Plains.

"As best anybody knows," writes Thom Hartmann in his Substack column, "the main cause of the Dust Bowl was the widespread deforestation of the central United States for cropland, combined with soil-destructive agricultural practices



Stefan Keller/Pixabay

and a widespread drought through much of the 1930s."

President Roosevelt ended it by starting the Civilian Conservation Corps (CCC), which planted more than three billion trees; built trails and shelters in over 800 parks; planted over 200 million trees in a belt from Bismarck, North Dakota to Amarillo, Texas; and planted seedlings on marginal or abandoned farmlands.

President Biden committed to revisiting the CCC or something like it to deal with today's climate emergency. On January 27, 2021, he issued an executive order on "Tackling the Climate Crisis at Home and Abroad."

On September 18, Senator Ed Markey and Representative Alexandria Ocasio-Cortez, along with 49 colleagues, wrote a public letter encouraging the President to implement his executive order and create a modern-day CCC. In the letter they state "...your Administration can realize the vision of a Civilian Climate Corps that establishes a unified front in the face of climate change - one that looks like

America, serves America, and puts good-paying union jobs within reach for more young adults."

Markey and Ocasio-Cortez, along with 49 colleagues also introduced legislation, the Civilian Climate Corps for Jobs and Justice Act of 2023, in both the House and Senate to bring such a program into existence. Over 25 environmental and other groups have endorsed this program.

President Biden has responded by rolling out the new Civilian Climate Corps. Its website American Climate Corps states, "The American Climate Corps will put a new generation of Americans to work conserving our lands and waters, bolstering community resilience, advancing environmental justice, deploying clean energy, implementing energy efficient technologies, and tackling climate change. American Climate Corps members will gain the skills necessary to have access to good-paying jobs that are aligned with high-quality employment opportunities after they complete their paid training or service program." Go to (www.whitehouse.gov/climatecorps/)

The program President Biden rolled out through executive action is not as ambitious as the one Markey and Ocasio-Cortez envisioned, but at least it is a start.

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Maine Housing and Climate

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based on models for reducing emissions.

For new construction, upgrades like these are perhaps "the single biggest no-brainer in the field," said Matt Rusteika of the Building Decarbonization Coalition.

The big potential users of fossil fuel power in most homes, he said, are the space heating and cooling systems, water heating, stove and oven, and washer and dryer. Where available, gas is commonly used to power these, and is a candidate for change-out. Maine has less home gas access than nearly any other state, putting it at a climate advantage.

"It can actually be cheaper to build a new home or a new building with electrification," Rusteika said, "than it is to build something with fossil fuels."

A 2022 law in Maine mandates that new construction funded by the state must meet a high-level energy efficiency standard, such as the Passive House certification or something similar, emphasizing electrification, healthy air quality and low, predictable energy costs.

Fossil fuel power is "not necessary, in a climate way" in new housing, said Naomi Beal, who leads *passivhausMAINE*. "It's dirty, it's expensive and volatile. ... The value of a Passive House-level approach is that the costs are small and super predictable."

But regulations to help decarbonize in new housing must strike a tricky balance, said the Affordable Housing Coalition's Mitchell — improving housing quality, sustainability and affordability, without making projects too expensive to build or otherwise slowing the pace of develop-

ment to house those most in need.

"There's kind of that sweet spot, because there's also a social equity issue involved in this," Mitchell said. "The cost of energy efficiency and addressing climate change shouldn't fully fall on the backs of people in need of affordable housing."

Rusteika said regulatory requirements can give developers more certainty, but aren't always needed at a time when climate-friendly building alternatives are becoming cost-competitive.

"A lot of people choose electrification on the merits," he said. "It's not an 'eat your vegetables' thing."

One case study is the West End Apartments, a two-building affordable housing complex in South Portland, Maine that opened half in 2021 and half this year. Some units were set aside to house asylum-seekers.

The complex was built to a near-Passive House standard mainly to cut operating costs, said architect Jesse Thompson. It has all electric appliances, heat and utilities, except for gas water heaters. These were the cheapest option when the project was designed, but electric water heaters might be preferable in the near future, he said.

"It's changing really, really rapidly," Thompson said. "The machinery's getting less expensive; the state is pushing much harder to do it."

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Heat Pump Performance

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during extreme cold snaps in the last couple of years.

Still, the myth of heat-pump insufficiency persists. Ironically, a nation with milder winters, the U.K., is one of the places Gibb has seen the misconception most. In media stories and social posts, people have reported being dissatisfied with their heat pumps. It can happen, Gibb acknowledged, but it isn't necessarily a reflection of the tech's capabilities, he said. "In many cases, they just got a bad installation."

These types of stories represent "a pretty dangerous line of misinformation," Gibb said, "because it erodes public trust in [heat-pump] technology when it can achieve very high performance." The U.K. installed less than a tenth of the number of heat pumps that France did last year.

What's more, companies in the fossil-fuel business have pounced on even slight declines in heat-pump efficiency as a valid reason to delay a transition to clean heat. For example, in July, U.S. utility Xcel Energy argued that heat pumps should play a limited role alongside the continued use of fossil gas as part of efforts to decarbonize Colorado, citing a recent report the utility had funded. Preliminary results found a modest drop in heat-pump efficiency, 5 to 12%, at higher altitudes — the testing facility was about a mile above sea level.

Xcel also stated that while heat



A heat pump keeps a waiting room warm. (public domain)

pumps do well above 40°F, "their performance degrades at lower levels."

For those reasons, "most homes using heat pumps for heat would require additional backup heating, either gas-fired or resistance electric heating," Xcel concluded.

"It's true that the performance does decline when it gets colder. That's a fact," Gibb said. But when "entrenched interests" use that to write off heat pumps, they're ignoring the fact that the technology still handles cold weather reliably — and more efficiently — than fossil-based alternatives.

Alison F. Takemura is a staff writer at Canary Media.

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