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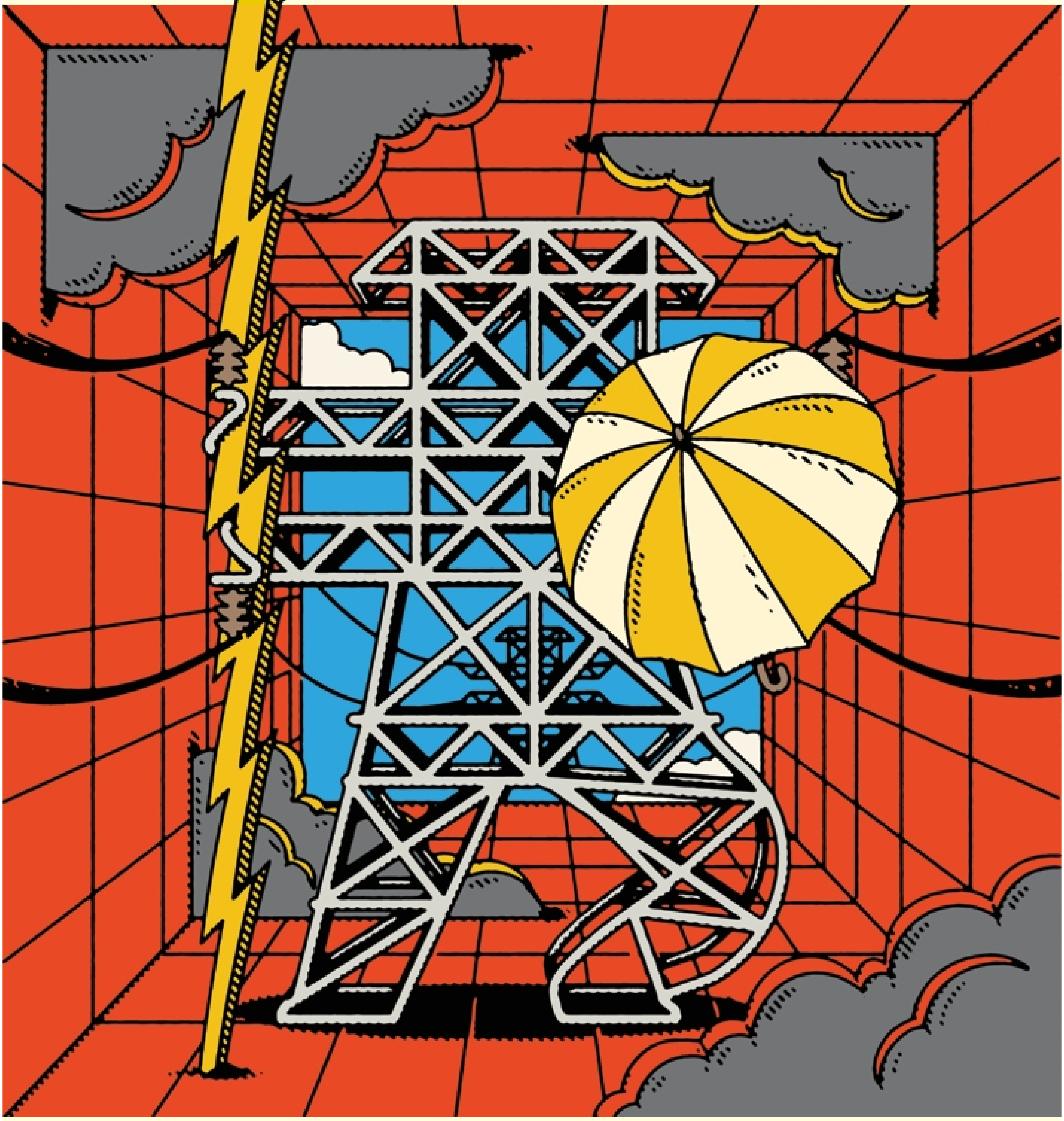

MICHAEL HADDAD

FIVE WAYS TO DISASTER-PROOF THE GRID

With extreme weather events—and power outages—on the rise, utilities and tech companies are looking for ways to keep the lights on in the future

BY AMY MYERS JAFFE

EXTREME WEATHER has been pushing the country's power grid to its limits—and wreaking havoc on homeowners and businesses.

Hurricanes, heat waves and other weather events have gotten more severe in recent years, driven by warming seas, rapid coastal erosion and record temperatures, among other factors. And that has taken its toll on the aging, overtaxed U.S. energy grid: Extreme weather events triggered 1,755 widespread power outages from 2014 to 2023—double the figure from the early 2000s, according to Climate Cen-

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The Best Ways to Cool a Home—Without Using AC

Architects and homeowners have long assumed air conditioning would keep people comfortable. Now they are looking to the past to lower temperatures.

BY WILLIAM BOSTON

AS THE WORLD warms, it's getting harder—and more expensive—to beat the heat. But architects, designers and homeowners are looking for ways to keep homes comfortable without air conditioning, or at least with less reliance on it.

For years, the idea of turning off the AC was unthinkable. Since home air conditioning became widespread in the U.S. in the 1960s, architects paid little heed to maximizing or minimizing a house's exposure to the sun or prevailing winds.

"We could build the same house anywhere on Earth, taking the house completely out of context," says Graham Irwin, principal architect at California-based Essential Habitat Architecture.

His firm is one of many that design or renovate homes with today's focus on energy conservation in mind—creating so-called passive houses, which meet a series of energy-efficient standards to be more climate friendly. "We normally see about an 80% reduction in energy use in the houses we work on," he says.

Throwing shade

One of the key features of a passive house is that it is heavily insulated and sealed up tight to keep warmth inside during the winter and cool air inside during the summer. Passive houses also incorporate passive cooling techniques, using architectural and natural methods to keep a house from heating up by blocking the sun and enhancing ventilation.

Take the home called the

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Inside

5 WAYS TO DISASTER-PROOF THE ENERGY GRID

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tral, a research organization on climate science. Hurricane Helene left about six million customers without power, according to the Edison Electric Institute, an industry think tank. Similarly, Hurricane Beryl left nearly two million customers without power earlier this year.

Worse may be on the way: The U.S. government's National Climate Assessment projects that we are due for even more extreme weather in the coming years unless climate change is curbed.

Now utilities, local governments, the U.S. military and tech companies, to name a few, are looking for ways to strengthen the energy grid and protect it from weather-related disasters. They are gearing up to apply AI to age-old problems like fortifying infrastructure and deploying repair crews. They are investigating technology like improved transmission lines and battery power to keep electricity flowing in emergencies. And customers are hunting for their own ways to prep for extreme weather, such as creating micro-electric grids that can operate independently of the main grid if need be.

Here are five promising ways to help keep the lights on.

Better predictions with AI

One critical way for utilities to battle extreme weather is to better prepare themselves for disaster. Which equipment is most vulnerable to storms or heat waves? Where are the best places to position work crews with a hurricane on the way?

In the past, utilities often had to estimate those things using historical data about severe weather in the area. Enter AI, which can give a more accurate reading of storm impacts before they happen, be more precise on what materials and equipment to stockpile, and figure out what specific kind of workers will be needed, and where they should be.

AI-powered predictive models for coastal flooding could, for example, identify substations where utilities need to upgrade from copper wiring to fiber-optic cables, which are more resilient to saltwater and can be replaced more quickly if need be. AI can even help utilities understand where wires and other assets are most at risk from interference from trees and other vegetation so they can be pruned before a disaster hits.

When an emergency does strike, AI can also help with logistics in real time, analyzing real-time updates from customers, first responders, drones and more. Then it can route and schedule teams based on changing conditions.

Bolstering batteries

In recent months, utilities have been adding large amounts of battery capacity to their grids, a move that can make a huge difference in times of extreme weather.

Power companies can inject surplus flows of power into batteries at low-demand times and then discharge them to meet any sudden surge in demand during emergencies, such as heat waves. This not only keeps power flowing to customers but also protects equipment from damage due to unexpected imbalances between supply and demand—something that is much more likely during extreme weather. Batteries have played a critical role this summer and autumn keeping grids on line in California and Texas when they were threatened by heat-related brownouts.

One problem: Most of today's battery installations are lithium-ion and discharge in just a few hours—not nearly enough to help out during outages that last for days or weeks. On the horizon, though, are new technologies like iron-air long-duration batteries or zinc-hybrid batteries that can allow utilities to store enough power to last for up to 100 hours.

Meanwhile, household batteries can also help utilities in times of stress. This takes the form of a system being piloted by several major utilities around the U.S.—so-called virtual power plants or VPPs.

Here is how it works: Utilities—or other VPP operators such as Tesla and Sunrun—contract with some customers to install battery-storage systems in their homes or businesses. These customers agree to share a portion of the electricity stored in their battery systems at certain times, and the VPP operators can then aggregate that extra electricity supplied by all of those individual batteries to support the wider grid.

In essence, the power from all of those individual batteries gets collected together and acts as one big power plant to provide the grid with needed electricity—either during times of routine fluctuation or emergency stress, like extreme weather.

VPPs have already been helpful in California—during heat waves, for instance—and are just starting to be used in places like Florida and New England that are susceptible to extreme weather events.

Going 'island mode'

Of course, batteries can only help utilities if power lines remain intact to keep supplying electricity. They won't be much use during a severe storm where lines get completely knocked out. For such disaster scenarios, some utility customers are taking matters into their own hands by installing systems that let them go "island mode"—and operate independently of the larger grid if it goes down.

That means installing a microgrid, a self-contained power-generating system covering a small, unified area, complete with its own power-generation sources, interconnection equipment and wires. Crucially, microgrids can automatically separate themselves from the main grid—and go into island mode—the instant a problem arises. So, devices, equipment and appliances connected to the microgrid won't be damaged or destroyed by an electrical surge.

More hospitals, big-box stores and community centers are installing these grids to keep the power on in case of emergency and help their communities in the aftermath of severe weather. The U.S. Army has been deploying microgrids and aims to have them at every installation by 2035. One U.S. Marines base in San Diego can go 21 days in island mode.

Increasingly, microgrid purveyors are tapping solar and battery storage. Solar panels are built to withstand 140 m.p.h. winds and can still generate some electricity, albeit at greatly reduced efficiencies, during a severe rain event.

Better, stronger transmission lines

Some utilities are beefing up their physical transmission lines, retrofitting them with higher-performance materials. Advanced conductors like carbon fiber replace steel with lighter, stronger materials and use denser annealed aluminum instead of aluminum strands. The lines don't change temperature as easily or weaken during extreme conditions, so they are less likely to heat up or sag in ways that create dangerous situations during extreme weather.

> Scientists are working to develop wire material that will make it easier to transmit electricity over long distances.

Scientists are also working on advanced superconducting materials to create wires that lose less or no electricity as electrons are transmitted over long distances. That will make it easier for different regions of the U.S. to draw electricity from each other to overcome outages and supplement supplies during emergencies.

Utilities are also trying to make power lines more effective during emergencies by making them smarter. Historically, utilities have been cautious about how much power to inject into power lines, often operating lines below their rated capacity, especially during times of weather stress. That way, they avoid overloading, which can lead to line overheating and possibly fire.

By using AI in real time, utilities can maximize electricity flows into wires and pinpoint when to reduce them to head off weather-related problems until conditions improve. A software and sensor system of this sort is being tried in New York state. Other AI products allow for predictive maintenance, sending notifications when equipment like wires or transformers are likely to fail in the next storm, and allowing them to be fixed ahead of time.

Controlling demand

Utilities are also looking for ways to manage customer demand for electricity—something that is critical during extreme weather. In a heat wave, for instance, people tend to crank up the air conditioner and keep it running longer. All that extra usage can cause instability in the grid and lead to rolling brownouts.

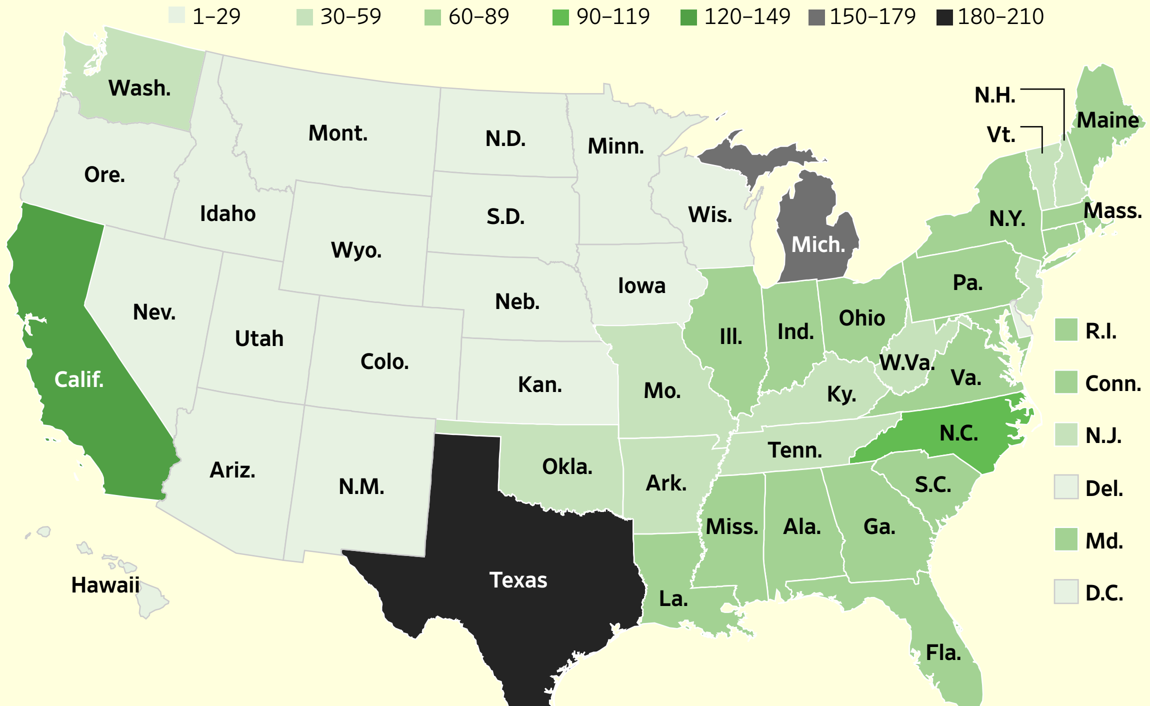
The answer may lie in "smart" technology that many people are already installing in their homes. They are using thermostats that they can monitor or adjust remotely, for instance, or arrangements where an internet-connected master control system monitors and manages smart appliances, lighting and EV charging.

Some utilities are joining with smart-thermostat providers to enroll customers in plans that allow the utility to remotely adjust the temperature in their homes during times of dangerously high demand. Customers receive discounts to their electricity bills for enrolling and participating.

Eventually, such programs will go beyond thermostats to an entire range of home appliances. Customers might give their utility permission to, say, change the timing of EV charging or reschedule the use of other nonessential household appliances, to ease the strain on the grid during emergencies like powerful storms or heat waves.

Already, California sends texts to homeowners during heat events, alerting them to adjust thermostat settings and unplug EVs, hot-tub heaters and large electronics during heat events. Someday, the utilities will be able to throttle back those nonessential appliances remotely.

Number of major* weather-related outages between 2000 and '23, by state



*Events that affect at least 50,000 customers (homes or business) or interrupt service of 300 megawatts or more
Source: Climate Central based on an analysis of the Energy Department's Form OE-417 reports

The Experts

Why Energy Efficiency Might Not Cut Emissions As Much as You Think

Many governments see energy efficiency as a key decarbonization strategy. In fact, some scenarios assume efficiency can drive approximately 40% of emissions reductions under the Paris climate accord.

For policymakers, the assumption is straightforward: Improving efficiency will lower energy consumption, which in turn reduces greenhouse gas emissions. And many prominent organizations support this assumption.

But a case can be made that strategies that rely heavily on efficiency to reduce emissions are bad bets. Historical data show that increased energy efficiency has gone hand-in-hand with *more* energy consumption over the long term, not less. I would argue that any decarbonization approach that fails to take this into account runs the risk of backfiring.

The paradox

The idea that that more efficiency can spur more consumption rather than less is known as the Jevons Paradox. Named after the British economist William Stanley Jevons, who first described it in his 1865 book "The Coal Question," the paradox challenges the intuitive belief that efficiency gains automatically lead to energy savings.

Critics who dismiss Jevons's idea often focus on consumer behavior. For example, it is hard to imagine that a driver would drive 50% more miles if purchasing a car that uses 50% less fuel per mile. They might drive a little more, but it wouldn't be enough to make a difference.

When you zoom out further to the global economy, however, you see that industry reacts much differently to increasing efficiency. More efficient firms generate greater profits, which leads to more investment, more production and, crucially, more energy consumption to support more food production and population. Efficiency makes it economically viable to extract and consume harder-to-reach energy resources, such as oil from hydraulic fracturing or wind from less windy areas, which then fuels the production of more machines, vehicles and industrial processes.

Consider these two questions: First, have we continually developed machines and processes that are more energy-efficient? The answer is yes.

Second, has global energy consumption continued to rise alongside this increase in efficiency? Again, the answer is yes, unequivocally so for the past two centuries.

These two points often help skeptics grasp the paradox. While efficiency isn't the sole driver of economic growth, it plays a significant role.

Faulty assumption

The real challenge comes when energy efficiency is presented as an economywide climate solution by itself. When policymakers use efficiency as a cornerstone of environmental policy without acknowledging its broader economic impact, they build their strategies on faulty assumptions.

Fortunately, recent research is starting to properly assess the relationship between energy, efficiency and growth. Metastudies show "economywide rebound effects" can erode more than half of the anticipated energy savings from efficiency improvements, undermining its effectiveness as a climate-mitigation strategy. My own research shows that it takes about six years, on average, for improvements in energy efficiency to lead to higher overall energy consumption. Additionally, an increasing body of work suggests that economic "productivity" can largely be explained by gains in energy efficiency.

What is the takeaway for policymakers?

If growth is the goal and you want to spur more of it, then keep promoting investment in energy efficiency with no other policies to restrict profits and investment. But if the goal is to balance growth with lower greenhouse-gas emissions, you have to direct investments toward low-greenhouse-gas technologies and away from high-greenhouse-gas technologies by penalizing emissions.

Energy efficiency is a valuable tactic for improving well-being by expanding access to energy services. However, we must confront its unintended consequences. By failing to account for the rebound effect, we risk being "surprised" that efficiency ends up driving more emissions. Jevons's insights from over 150 years ago still hold today. It's time we incorporate them into climate strategies that genuinely reduce emissions—before another 150 years pass us by.

—Carey King, research scientist and assistant director at the Energy Institute at the University of Texas at Austin, and author of "The Economic Superorganism: Beyond the Competing Narratives on Energy, Policy, and Growth."

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