SURGING POWER OUTAGES

and Climate Change

September 14, 2022

CLIMATE CENTRAL

Surging Power Outages and Climate Change

Summary

Large-scale power outages are increasingly common across the United States. Damaging storms, extreme weather, and a growing demand for electricity are straining our nation's aging power infrastructure.

Disruptions in the electrical grid affect millions of people each year, putting public health and safety at risk. Power failures have cascading effects on other infrastructure and cost billions of dollars annually.

Between 2000 and 2021, about 83% of reported major outages in the U.S. were attributed to weather-related events. Climate change is increasing the frequency and intensity of the extreme weather that wreaks havoc on our power grid—from wildfire to heat waves and hurricanes.

Climate Central analyzed data on major power outages in the U.S. from 2000-2021. This supplementary report:

- summarizes key findings about power outages and weather events
- illustrates how extreme weather is affecting our electrical infrastructure
- outlines expectations for our power grid in the face of climate change

Download the data

The power grid is a foundational, but vulnerable, part of America's infrastructure.

People depend on the complex electricity system that serves homes and businesses across the U.S. This system—including power generation, high-voltage transmission, local distribution, and the end-use customers—is connected through an intricate network spanning the country.

But the nation's aging electrical infrastructure is in need of critical updates to improve its reliability and its resilience to potential disruptions. Even as the energy sector takes measures to meet America's increasing demands for electricity, the capacity and reliability of the electricity system are lagging. The grid remains vulnerable to large-scale outages caused by cascading power failures, cyber-attacks, and perhaps most significantly, extreme weather.

Climate change exacerbates risks throughout the power system.

Extreme weather events such as hurricanes, wildfires, ice storms, flooding, and heat waves are growing in frequency, duration, or intensity with climate change. These are some of the leading causes of major power outages, and their increases put stress on an already-vulnerable power grid.

The extreme weather made more common by climate change both increases our demand for electricity and diminishes our ability to supply it. Heat waves raise electricity demands for cooling. At the same time, warming temperatures and drought can reduce the available surface water

needed for cooling power plants, thereby reducing the electricity they can generate.

The majority of the nation's electrical infrastructure was established decades ago and wasn't built to function in our present-day climate. As conditions continue to shift, systems will be exposed to more extreme weather throughout their operational lifetimes, potentially impacting their performance, resilience, and capacity to meet electricity demand.

Much of the U.S. transmission and distribution network is above ground. Transformers, transmission wires, and utility poles are all vulnerable to severe weather, particularly high winds, heavy rain, ice, snow, and lightning. Even in areas where power lines are buried, flooding can lead to loss of power, as occurred in Houston, Texas during Hurricane Harvey. Damage along the hundreds of thousands of miles of high-voltage transmission lines or the millions of miles of local distribution lines can impede power delivery to customers.

Who (and what) is at risk when the power goes out?

Power losses to individual homes can be more than just an inconvenience. A lack of refrigeration, heating, and air-conditioning can be dangerous or even deadly, especially during extended outages. There is a range of potential health consequences, particularly for those who rely on electricity for critical medical equipment.

Older people and individuals with disabilities or certain health conditions may be especially vulnerable during weather-related power outages. And the consequences of power loss are compounded

Box 1. Utility-controlled power shutoffs mitigate wildfire risks in the West

Utility companies in California are authorized to implement public safety power shutoffs (PSPS) to reduce risk of equipment-related ignitions during extreme fire weather days—a combination of high heat, low humidity, and strong winds.

Although damage to power lines causes only a small percentage of wildfires, it contributed to several of the deadliest and most devastating wildfires in California's recent history, including the 2018 Camp Fire and 2021 Dixie Fire.

Shutoffs are meant to minimize the risk of devastating losses for communities vulnerable to wildfire. Nonetheless, PSPS affect the daily lives of millions of Californians, which comes with other costs to safety, well-being, and the economy. It's not possible to compare these damages with those of the potential wildfires avoided during shutoffs.

Affected communities receive outage alerts before the shutoffs, sometimes up to a week in advance, based on weather forecasting. As the number of fire weather days increases in the West, PSPS could become a new normal.

California's PSPS are the earliest and most well-known of these "de-energization" protocols. Oregon—another western state with increasing fire weather days—has implemented a similar model. It remains to be seen whether safety shutoffs will become common practice in other fire-prone western states, or if communities and utilities will resist power loss as an acceptable precaution against wildfire damages.

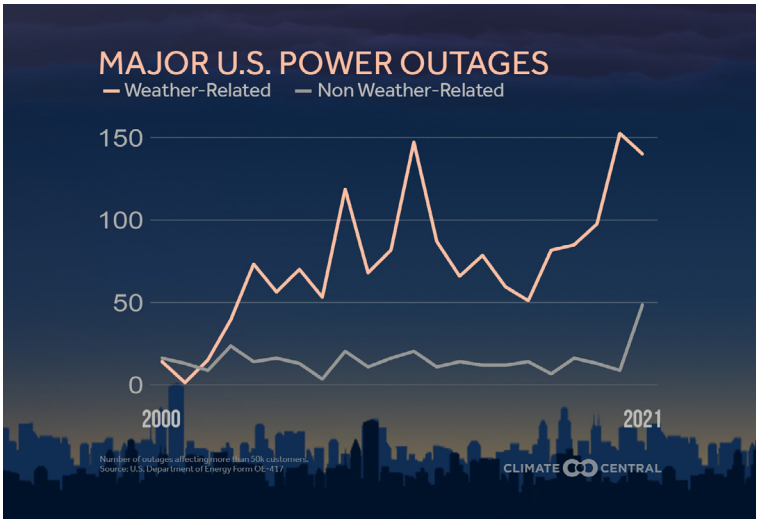
by the precipitating events, such as flooding, wildfire, or extreme temperatures.

Large-scale power outages can have cascading effects on other components of infrastructure. They can affect communication and transportation networks, as well as limit access to clean water, food, and critical healthcare.

The full cost of power outages (including indirect costs to people and businesses) is difficult to calculate, but estimates of the annual cost to the U.S. economy range from tens of billions to well more than one hundred billion dollars annually. Widespread power outages are a major contributing factor in the billion-dollar weather and climate disasters in the U.S. each year.

Major power outages are increasingly common. Extreme weather is often the cause.

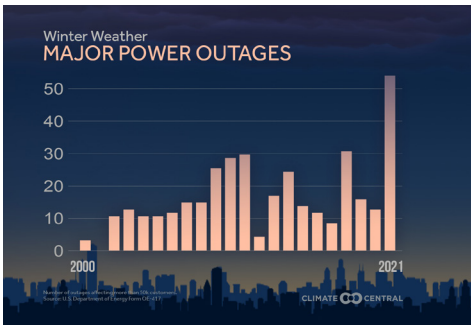
Climate Central analyzed U.S. power outage data between 2000 and 2021, as submitted by utility companies to the federal government and the North American Electric Reliability Corporation, a non- profit regulatory authority whose mission is to assure the reduction of risks to the reliability and security of the grid. Major power outages described in this report are large electrical disruptions during which at least 50,000 customers lost power.

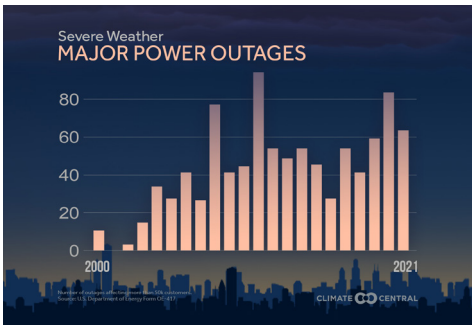


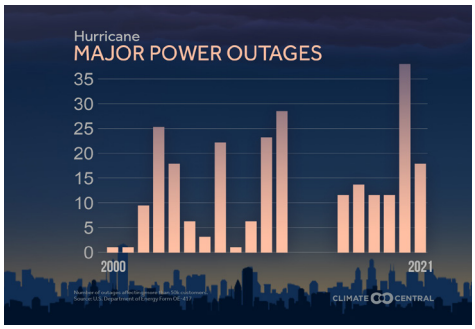
- The data show 64% more major power outages during the decade from 2011-2021 than from 2000-2010.
- During the 22-year period analyzed, 83% of all reported power outages can be attributed to a weather-related event.
- Between 2011 and 2021, the average annual number of weather-related power outages increased by roughly 78% compared to 2000-2010.

Types of extreme weather events

Utilities are required to describe the cause when reporting weather-related power outages, but there are no set criteria for such descriptions. In many cases, events are simply listed as storms or severe weather, which may refer to a broad range of conditions. For example, outages attributed to





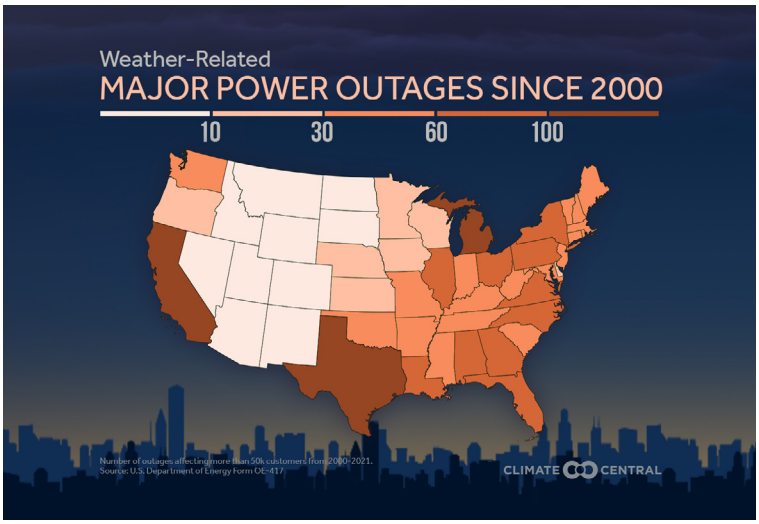


"severe weather" by utilities weren't necessarily caused by conditions that meet the meteorological criteria for severe weather. An inconsistent level of detail makes it difficult to fully assess how specific types of extreme weather affect the power grid.

To fill this knowledge gap, Climate Central analysts combed report details and relevant media coverage to appropriately assign documented weather events to individual outages. This updated analysis captures weather-related outages that were not coded as such in previous Climate Central analysis.

From 2000-2021, there were 1,542 weather-related power outages. These events are sorted into five main categories: **severe weather, winter weather, hurricanes, extreme heat, and wildfire.**

- Severe weather—such as high winds, rain, and thunderstorms—caused 58% of weather-related power outages between 2000-2021.
- Winter weather—including snow, ice, and freezing rain—accounted for 22%.
- At least 15% were caused by hurricanes/tropical storms.
- Extreme heat was responsible for 29 outages (1.9% of weather-related outages) during the 22-year period. In some cases, the utility was unable to meet electricity demand during heat waves.
- The 37 major power outages attributed to wildfire account for a small portion (2.4%) of the total weather-related outages since 2000. A majority of these outages (65%) were concentrated in a recent five-year period (2017-2021). About one-third were preemptive utility shutoffs due to wildfires or fire weather.



Box 2. Hurricane Sandy: the storm that brought floods, high winds, and snow to nearly half the U.S.

On October 29, 2012, Superstorm Sandy made landfall near Atlantic City, N.J. Although New York and New Jersey suffered the most damage, the storm had an immense geographic range. Sandy brought heavy rain, high winds, and flooding to nearly half the states in the U.S. Some even saw snow at higher elevations. Unsurprisingly, the storm caused significant damage to electrical infrastructure. There were 21 states along the East Coast and stretching into the Midwest that experienced power outages, and 16 states reported outages to more than 50,000 customers.

Weather events across the U.S.

Because of the interconnected nature of the grid, large multi-state areas can be impacted by outages in a single state. Furthermore, some types of extreme weather, including winter storms and hurricanes, affect large areas and can cause power interruptions across regions. Power outages that affected multiple states and regions were counted in each state and region's total number of events, but were counted only once in the national number of events.

The analysis shows regional variation in the number of weather-related outages—which partly reflects the relative population densities and infrastructure age. The greatest number of reported

Region	Number of weather-related outages	Number of outages attributed to severe weather	Percent severe weather outages
Southeast	474	241	51%
Midwest	363	291	80%
Northeast	346	178	51%
S. Plains	218	118	54%
Southwest	152	54	36%
Northwest	67	52	78%
N. Plains	17	9	53%
Hawaii	2	2	100%
Puerto Rico	1	0	-

Alaska had no reported outages

outages was in the Southeast. The Midwest ranked second in total outages, but first in outages due to severe weather. The Northeast was third in both total and weather-related outages. In total, across all regions, severe weather was the most common cause of outages. Severe storms are localized, short-lived events with limited historical records, which makes it difficult to link their occurrence to global climate change.

The top five states with the most reported weather-related power outages are **Texas, Michigan, California, North Carolina, and Pennsylvania.**

Box 3. February 2021 Winter Storm and Cold Wave

Winter weather accounted for nearly 22% of power outages in Climate Central's analysis. The most common winter weather-related causes of blackouts are high winds and snow downing trees onto power lines, and frozen transmission equipment. The costliest winter storm on record was the February 2021 Winter Storm and Cold Wave, when temperatures dipped far below normal from Nebraska to Texas resulting in multiple days with below-freezing temperatures.

The February 2021 event caused power outages throughout much of the South, and especially in Texas. According to NOAA, nearly 10 million people were without power at the peak of the outages. The sustained extreme cold conditions also caused or contributed to an estimated 210 deaths in Texas due to water shortages, cold exposure, ice accidents, and carbon monoxide poisoning.

The power outages across Texas in February 2021 were as much a result of extreme weather as of human unpreparedness. Much of the state's energy infrastructure (including all types of generation technologies) were not winterized, leaving components vulnerable to freeze. Additionally, Texas operates its own grid independently of the two main national grids, making it difficult to draw power from elsewhere in times of need.

RECENT TRENDS

Several states in this analysis saw notably high numbers of major outages in the last few years. As extreme weather events become more common and electrical infrastructure continues to age, the number of outages is only likely to increase.

- The total number of major power outages in 2021 was 112% higher than the annual average between 2000 and 2021. Weather-related outages in 2021 were about 88% higher than the long-term average.
- Texas utilities reported 20 weather-related outages in 2019, 19 in 2020, and 41 in 2021. This three-year period accounts for 44% of Texas's total weather-related outages since 2000. Severe or winter weather caused the majority of these outages (76%), followed by hurricanes (21%).
- Michigan's highest-ranking year included in the analysis was 2021 with 14 major power outages—all attributed to severe weather.
- In California, utilities reported 44 outages between 2019 and 2021. This three-year period accounts for more than one-third of the state's total weather-related outages since 2000. At least 14 of these outages were in response to growing wildfire risks.

Building a more resilient power system

Ultimately, cutting emissions is the most meaningful action that can be taken to slow the rate of warming and the mounting stress on our power grid, and to allow more time to plan and adapt to our changing climate. Upgrading the nation's electrical infrastructure to become more resilient and reliable will be expensive and challenging. But there are a number of promising and innovative solutions to build electricity security into our system now, especially alongside the anticipated near-term growth in renewable energy capacity. Here are a few:

- Microgrids are self-sufficient energy systems with a smaller, distinct geographic footprint, such as a college campus, hospital complex, or neighborhood. Their relatively small scale also makes microgrids more easily powered by renewable energy sources, which has the added benefit of reducing emissions from power generation.
- Smart grid technologies include sensors that allow operators to assess grid stability and provide consumers with better information about outages.
- Hardening the grid refers to measures that fortify the system against damage. Examples include tree trimming along power lines, replacing wooden electrical poles with steel or concrete, and burying overhead transmission lines.
- Bidirectional charging is not yet a standard feature for most electric vehicles, but manufacturers are exploring capabilities that would allow vehicles to power homes during blackouts and serve as an energy storage resource for the grid.
- Incentives can further encourage customers to cut back on usage during peak times.

Box 4. Generator safety

The humming of generators is a (perhaps unpleasantly) familiar sound following power outages and storms. While they may keep the lights on or the refrigerator cold, portable generators can be deadly if operated incorrectly. A recent report estimates that 85 people die annually from carbon monoxide poisoning associated with use of a gas-powered generator. It's important to take precautions–never use a generator indoors, follow safety procedures, and wear appropriate personal protective equipment, such as earplugs, when operating them. As the technology advances, bidirectional charging with electric vehicle batteries can be a potentially safer, low-carbon alternative to gas-powered generators during blackouts.

Methodology

Power outage data from 2000 to 2021 was collected from the U.S. Department of Energy's Form OE-417 reports. Major outages are considered to be events that affected at least 50,000 customers. For the purpose of our analysis, we consider only power outages (including blackouts and voltage losses), fuel supply emergencies, and emergency appeals for reduced electricity usages where there was a reported number of customers affected or power lost–and where outages were attributed to weather- or wildfire-related causes. We do not include reports of vandalism or cyber-attacks. Regional definitions broadly correspond with those outlined in the Fourth National Climate Assessment with the exception of Hawaii and Puerto Rico. Power outages that affected multiple states and regions were counted in each state and region's total number of events, but were counted only once in the national number of events.