Power After the Storm

Achieving Grid Resilience in a Climate-Changed World

HIGHLIGHTS

Communities across the central United States are facing a harsh and dangerous reality: extreme weather events have caused all of the last decade's biggest blackouts, each time leaving hundreds of thousands of customers without power at the very moment it was needed most.

As climate change can exacerbate extreme events like thunderstorms, hurricane-driven rain, and snowstorms in the region, the need for science-based, proactive grid modernization is more pressing than ever. The responsibility to keep the lights on amidst this climate reality—and ensure that underlying energy injustices are not perpetuated—falls particularly on utilities, regional transmission organizations, and state leaders.

Rachel Licker

Susanne Moser

Sam Gomberg

Amanda Fencl

Sital Sathia

Jayson Toweh

January 2026

www.ucs.org/resources/power-after-storm

https://doi.org/10.47923/2026.16071

Union of Concerned Scientists

Executive Summary

The nation's power grid is highly vulnerable to damage and prolonged outages during extreme weather. Utility customers are bearing the consequences. The central United States has seen much of such damaging weather extremes, whether the severe thunderstorms that roll in over the Great Plains, leaving downed trees and power lines in their wake, the Upper Midwest winter storms, producing ice buildup that interferes with electricity transmission, or the rain-heavy Gulf Coast hurricanes that bring down utility poles and flood substations. These expansive extreme weather events can leave residents across the region without power for days and even weeks, at times stranded in dangerous conditions while increasingly burdened with grid repair and recovery costs.

Unfortunately, this region faces more extreme weather events in the years to come as we continue to burn fossil fuels that cause our climate to change and make these extreme events more likely. For a climate-changed future, we need a resilient grid where the physical infrastructure, those who manage it, and those who are served by it would be prepared and able to withstand and recover from storms. A more resilient grid would also lessen the frequency and severity of outages and help ensure that communities benefit equitably from greater reliability.

Such a climate-resilient electricity grid is within reach. Right now, investment decisions are being made for a grid that is expected to reliably serve consumers until 2075 and beyond. As the sector plans and invests in upgrading and building our future grid, making critical choices that consider climate change will mean the difference between an electricity grid sturdy enough to keep the power on for millions of homes and businesses versus greater challenges from electricity disruptions and unaffordable energy costs.

In this report, we analyze the last decade of power outage data in the central United States, alongside media reports and peer-reviewed science, to explore three key questions:

> (1) Which extreme weather events have been most consequential for power outages over the last decade?
>
> (2) What can we learn about the patterns of impacts from the worst of these outage events?
>
> (3) How are the extreme weather events most consequential for power outages in this region expected to change because of climate change?

To chart a path toward a more equitable, climate-resilient grid, we look at what climate science is telling us about extreme weather events and their effect on power outages in this vulnerable region of the nation. Our analysis shows the following:

Over the last decade, all the 100 worst outage days in the central United States were caused by extreme weather. Every one of the study region's top 100 outage days between 2014-2024, as measured in maximum number of customers affected, was associated with a large-scale extreme weather event. Severe thunderstorms (including derechos, or, long lines of severe thunderstorms leaving widespread damage from high winds), hurricanes, and severe winter storms with large footprints damaged infrastructure, leaving thousands—and at times, hundreds of thousands—of customers without power. The most damaging power outages were nearly always caused by compounding events, such as a winter storm with a tornado outbreak or a hurricane with coastal and inland flooding.

Over the study period, the 10 worst outage events in the region all occurred since 2020. Many of them were compound extremes, and some occurred one after another, leaving little time for recovery and deepening social inequities. This record of outages provides a preview of what is to come: As the climate warms, extreme weather events are expected to become both more frequent and more severe. The inequities that leave some communities more vulnerable to power outages today are at risk of being amplified in communities marginalized by protracted legacies of under- and disinvestment. Investing in grid resilience is inseparable from investing in energy justice so that communities historically least prepared to withstand and recover from extreme events are not left vulnerable to even greater future risks due to outages.

The extreme weather events that are expected to worsen across the central United States heighten the need for science-based resilience planning. Aspects of each kind of extreme weather event most consequential for power outages are expected to worsen in the coming decades as the climate continues to change. Severe thunderstorm activity is projected to increase in much of the region, hurricanes that make landfall are projected to have a higher rate of rainfall, and snowstorms may intensify in the places they still occur. To avoid a concurrent increase in major power outages, it is critical that decisionmakers engage now in science-based resilience planning.

Power sector actors at all levels have a role to play in building grid resilience. Depending on the investments needed, the responsibility for a more climate-resilient grid falls on a number of actors, including local utilities, states, regional grid operators, and federal regulators. To best prepare the region's power grid and the communities affected by outages for climate change, we recommend the following three key resilience-building strategies:

- **Understand the risks posed by extreme weather and climate change.** Climate risk assessments must be specifically focused on the electricity sector and use the best-available and most up-to-date forward-looking science to understand the risks to the grid and how these risks should be mitigated or addressed.

- **Accelerate the transition to an electricity grid powered by clean energy.** Despite a current lack of federal leadership, states and utilities must continue to reduce planet-warming emissions to decrease the risk of ever-worsening extreme weather risks. The more quickly society decarbonizes, the less intense the impacts of climate change will be.

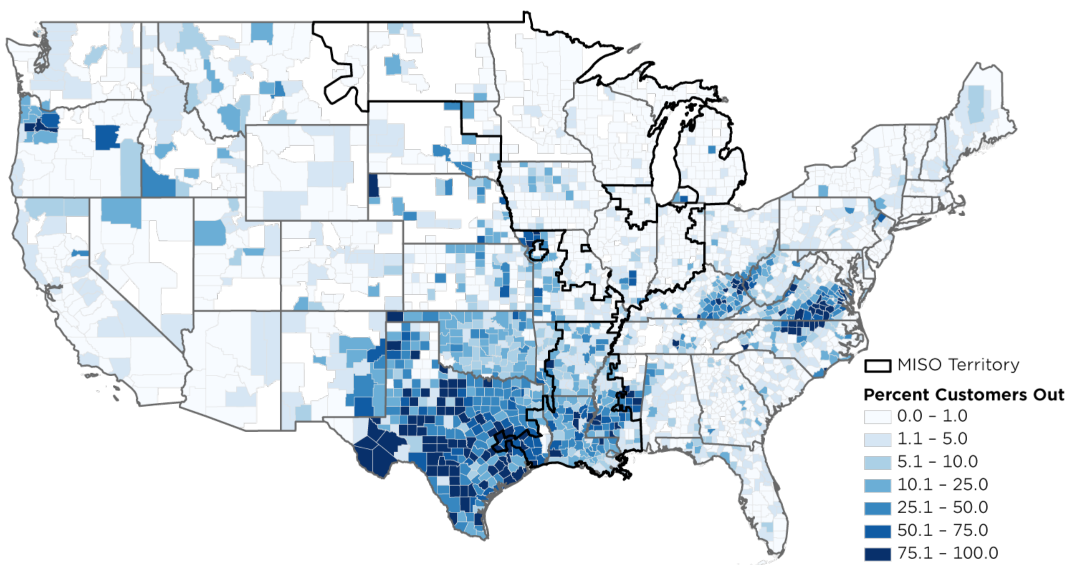
- **Engage with communities.** Properly building an equitable and resilient electric grid requires meaningful community participation and ownership in decisionmaking to ensure that the investments meet the needs of all the communities the grid serves.

Winter Storm Uri: A Defining Moment in the Need for Grid Resilience

In February 2021, Winter Storm Uri hit the central United States with crippling sleet, freezing rain and ice, high winds, severe tornadoes, and thunderstorms with hail, followed by extremely low temperatures (NWS 2021c). A total of 170 million people across the nation were affected, but none worse than the Texans who lost power—for up to five days—in frigid temperatures (Figure 1). A later analysis concluded that 700 people died in Texas alone, many more than officially recognized, and many from prolonged exposure to cold (Aldhous, Lee, and Hirji 2021; TX DHS 2021). Uri was also the most expensive Texas winter storm (Irwin 2024; Snyder 2024; Troutman Pepper Locke 2024).

In Texas, where the electricity grid is largely isolated from the rest of the country, the widespread failure of many power sources—disproportionately gas but also coal, wind, and nuclear—received intense criticism (see Arbaje and Specht 2024). In other regions affected by the storm, particularly the Midwest, the value of an electric transmission system that can access power resources across a larger geographic footprint was on display as electricity from regions further east and less affected by Uri was imported to maintain power (Goggin 2021; Goggin and Schneider 2022). In southern states like Louisiana and Mississippi, a mixture of power plant outages and more limited grid connection meant Uri's impacts were severe, albeit not to the degree that Texas experienced (MISO n.d.).

Figure 1. Maximum Percentages of Customers Without Power During Winter Storm Uri



County-level power outage data during Winter Storm Uri for the continental United States. Map shows the maximum percentage of customers out between February 12 and 19, 2021, as well as the Midcontinent Independent System Operator's (MISO) territory, the regional transmission organization responsible for much of the central United States.

SOURCE: Brelsford et al. 2024 for derived totals.

Much like wildfire events in the West, Uri became a defining event for the various actors that oversee the buildout, maintenance, and operation of the bulk power system in the central

United States. Grid resilience—the ability of the power system to anticipate, prepare for, withstand, and ultimately recover from extreme weather events—was thrust to the forefront of priorities for a much broader range of regulators, decisionmakers, and other interested parties, including UCS. But nearly five years since Uri, the need remains for proactive, science-informed strategies to understand the risks posed by extreme weather (including, but not limited to, winter storms) and to mitigate those risks through cost-effective investments in the grid infrastructure for a climate-changed future.

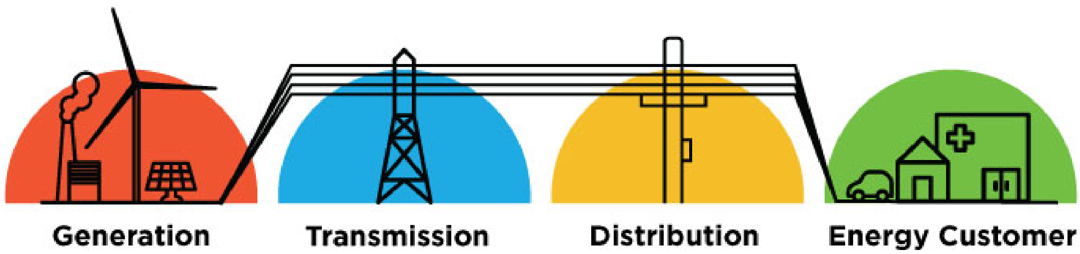
Weather-related power outages like what unfolded during Uri have been on the rise across the United States over the last two decades (Climate Central 2020; Climate Central 2024). And because of climate change, many of the extreme weather events that drive power outages are expected to worsen through the century (Marvel et al. 2023). In the face of these challenges, we need grid decisionmakers to critically consider climate resilience in how they plan for, invest in, and achieve a modern electricity grid that minimizes severe impacts and serves everyone equitably.

The electricity grid is a complex system that connects utility customers to reliable power through a broad network of power plants, transmission infrastructure, and distribution systems (Figure 2). During extreme weather events, failures can occur at any of these points and affect a much larger geographic area than just where those failures occur. Decisionmaking is broadly spread and interconnected: Responsibility for approving infrastructure investment decisions and ensuring they are responsive to the risks posed by extreme weather can sit at the utility, state, regional, or federal level, depending on which aspect of the grid is being addressed. Often these responsibilities overlap, necessitating robust coordination and communication between the responsible entities.

Efforts to build resilience must address risks at all levels of the grid. Shoring up local infrastructure is just as important as weatherizing power plants. As Uri made clear, one important but often overlooked necessity for increasing grid resilience is developing a more robust and interconnected bulk transmission system—the network of high-voltage wires that move electricity from the power plant to the local distribution system. The grid investments that improve connections between regional grids and even between utilities within a region increase interdependence and redundancy within a stressed grid, and are a critical element of building a more resilient transmission system and transitioning more cost-effectively to clean energy. Both are key to addressing the risks posed by climate change. The utilities, states, and regional grid operators responsible for investing in new transmission infrastructure must account for climate change and its potential to worsen extreme weather events. Failure to do so is irresponsible and puts the system and its communities at risk.

Achieving a more resilient grid begins with understanding the risks posed by extreme weather in terms of both the severity of potential future extreme weather events and the frequency of these events. New transmission lines typically are in service for several decades, so they need to be built to withstand future risks. Doing so requires being informed of what science can tell us about expected conditions. In this context, climate change—and how a warming planet will affect the severity, frequency, and timing of extreme weather events—is a critical consideration. Currently, utilities, states, and regional grid operators are making investments that will be expected to reliably serve consumers until 2075 and beyond. Investments made today without consideration of the significant climate change that will occur in that time frame will mean harmful power disruptions, wasted money, and failed infrastructure. Recent research found that investing in climate-resilient transmission infrastructure now will help reduce costs by the year 2100 (Fant et al. 2020).

Figure 2. The Electricity Grid Is a Complex System Connecting Energy Generation to Customers



The electricity grid is a network of power plants that generate electricity, of transmission line infrastructure that moves electricity long distances, and of distribution systems that deliver energy to customers—commercial, industrial, and residential. The affected grid component determines which entity is responsible for making infrastructure decisions: For generation, it is states and utilities; for transmission, it is regional transmission organizations (RTOs), states, and utilities. The federal government regulates the grid's generation and transmission components and ensures that those responsible are addressing extreme weather risks.

In building toward a resilient grid, we must also acknowledge that households and communities are not equally vulnerable to outages, nor are they equally able to respond. Resilience planning that overlooks these inequities simply shifts much of the burden of grid failure onto those least able to bear it. In practice, this means that decisions about how to invest, where to site new infrastructure, how to prioritize post-outage power restoration, and who participates in the decisionmaking process will determine whether all communities are strengthened or existing inequities are deepened. In this way, climate resilience and energy justice are interconnected technical, social, and political dimensions of the power system.

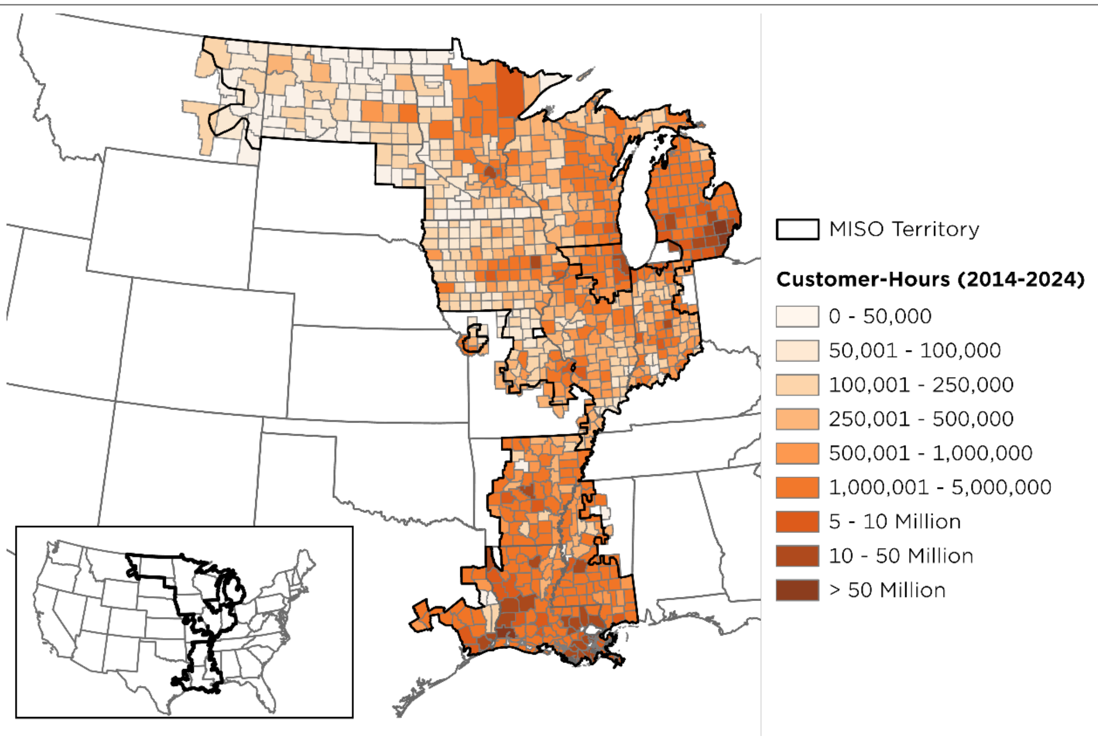
Identifying Climate-Related Risks for Power Outages in the Central United States

This analysis provides an overview of recent extreme weather events, subsequent power outages, and their effects on communities in the central United States. We focus on the territory covered by the Midcontinent Independent System Operator (MISO), the regional transmission organization (RTO) whose territory covers much of the central portion of the United States, serving more than 45 million people from Minnesota to Mississippi. We use MISO boundaries as delineated by the US Energy Information Administration, focusing solely on the territory included in the United States (EIA 2025). We include several counties in Illinois that are not part of the MISO system but that warrant inclusion because of existing and planned transmission interconnections in the region (see Figure 3). We refer to this territory collectively as MISO+. Using detailed, county-level power outage data from Brelsford et al. (2024), we examine power outages within the MISO+ region over the decade of 2014 to 2024. We couple these findings with a cursory analysis of news reports and post-event summaries to identify the causes and consequences of the worst outage events during this period.

To provide an outlook on the climate-related risks facing the region's power system, we conducted a literature review of the kinds of extreme weather events that have resulted in the most consequential power outages over the last decade and how these events are likely to change across MISO+ over the remainder of this century as a result of human-caused climate change. We conclude with recommendations for communities, states, utilities, and regional grid operators that, if implemented, can begin the process of proactively and cost-effectively mitigating the risks posed by extreme weather to the electric grid and the communities it serves.

To begin to understand the community-level impacts of power outages over time, we quantify outages in terms of population without power using the unit of customer-hours (the product of the number of customers affected by an outage and its duration). Metrics like this help shift power outage discourse and planning from being focused on reliability, where the grid is shaped around day-to-day, average uncertainty, to being more focused on equitable resilience, where the grid is shaped by its ability to incorporate the possibility of high-impact, lower-frequency events and consider the consequences for communities more holistically (Gomberg et al. 2025; Petit et al. 2020).

Figure 3. Total Power Outage Exposure Across the MISO+ Region, County-Level Customer-Hours Between 2014–2024



Customer-hours account for how many and how long customers were affected by power outages in a particular location. MISO's territory, shown within the black outline, excludes Chicago, Illinois (in Cook County), and several counties around it.
SOURCE: Brelsford et al. 2024 for derived totals.

To establish a baseline understanding of regional dynamics, we first examined incidents of power outages driven by extreme weather and other causes by calculating the total number of customer-hours that occurred over the last decade for each county in MISO+. We found that power outages occur unevenly across the region, and some regions are affected more frequently than others. For example, most of the counties in Michigan and Louisiana experienced more than 1 million customer-hours of power outages from 2014 to 2024, as did much of MISO's territory in Arkansas, Mississippi, and eastern Wisconsin—representing some of the areas most heavily affected by power outages in the MISO+ region (Figure 3).

Extreme weather events repeatedly drove widespread power outages over the last decade.

Each of the top 100 worst days in the region in terms of the number of customers affected by an outage was associated with a large-scale extreme weather event. Severe thunderstorms (including ones that generated derechos, tornadoes, and/or high winds), hurricanes, and winter storms frequently interfered with the availability of power for hundreds of thousands of energy customers, often for multiple days. More than half of the worst 100 days (57 percent) occurred in summer, versus 13 percent in spring and 15 percent in both fall and winter, mirroring when extreme weather events that damage infrastructure are currently most likely to occur in MISO+.

All of the 10 largest power outage events over the studied decade occurred since 2020.

We looked at the 10 largest power outage events in the MISO+ territory as determined by the greatest number of customers without power on a single day to better understand the experiences of communities and grid operators. Each event lasted for multiple days and was associated with compound weather events occurring over a large geographic region. The following section provides more detail about these large-scale outage events, which we list chronologically by their worst day, or the day the maximum number of customers were affected.

June 11, 2020 – Derecho. A long line of severe thunderstorms leaving widespread damage from high winds is commonly known as a derecho. The remnants of Tropical Storm Cristobal combined with an upper-atmosphere low pressure system over the Great Lakes region to produce a derecho, wind gusts of up to 75 miles per hour (mph), hail, several confirmed tornadoes in Illinois and Ohio, and another in western Pennsylvania rated an EF2 (Erdman 2020; NWS 2020d; the intensity of tornadoes is measured by wind speed and the associated severity of damage, using the Enhanced Fujita, or EF, scale). More than 450,000 customers lost power over the course of the two-day sequence of heavy thunderstorms, most of them in Michigan (Childs 2020; Haddad 2020; NWS 2020f). The derecho damaged trees, downed power lines and poles, wrecked roofs and buildings, and blew over several semitrailers. Luckily, only one person was injured when a tree fell on a car (Agar 2020; Childs 2020; Erdman 2020; NWS 2020e; NWS 2020f). Cristobal was one of the westmost-tracking tropical storms ever recorded, and the derecho it produced was the third to hit the United States in a single week's time (NCEI 2020).

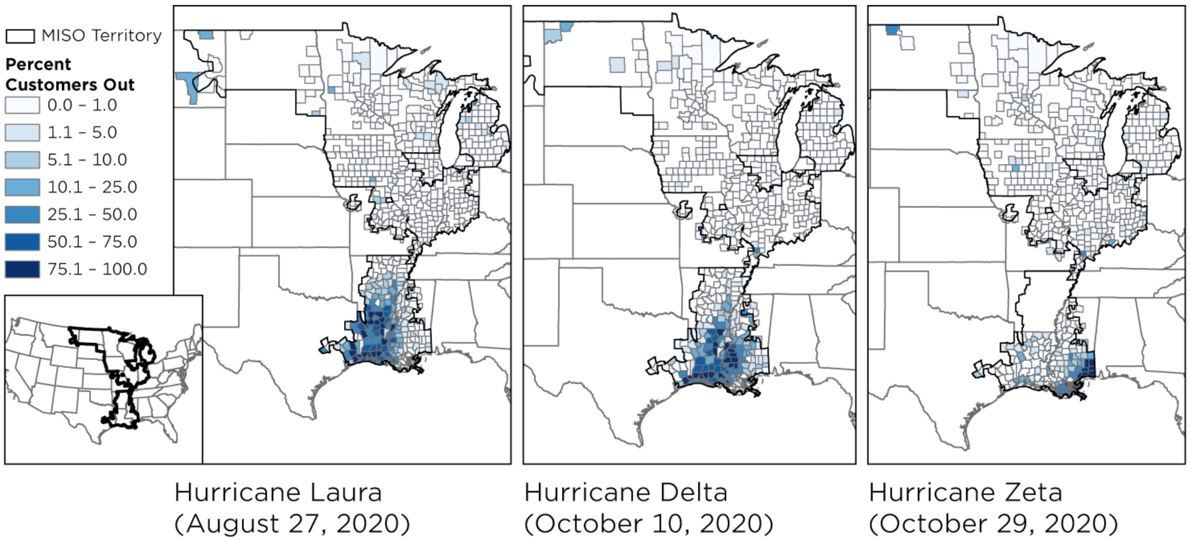
August 11, 2020 – Derecho. Two months later, another derecho crossed parts of South Dakota, Nebraska, Iowa, Illinois, Wisconsin, Indiana, Michigan, and Ohio. The worst-hit areas in central Iowa to north-central Illinois experienced average wind gusts of 70–80 mph, with maximum wind gusts of over 100 mph. In addition, the event produced 26 weak tornadoes rated EF0 to EF1, with wind speeds reaching between 65–110 mph in Iowa, Wisconsin, Illinois, and Indiana. On its worst day, nearly 1.7 million customers across the Midwest were left without power (Brelsford et al. 2024). Together, these storms caused a few dozen injuries and catastrophic wind damage to trees and crops, particularly in Iowa and Illinois, resulting in what was then the costliest thunderstorm event ever recorded in the United States, estimated to cause at least $11 billion in damages (NWS 2021a). According to the National Weather Service (NWS), "Damage to power lines was also so extensive that power outages were visible from space at night. . . . Widespread, long-duration power outages occurred across the area, with some parts of Cedar Rapids [Iowa] without power for about two weeks" (NWS 2021a). Some cities experienced extensive loss of urban tree cover, and this loss of canopy "impacted socially vulnerable populations at a higher rate" (IDNR 2025).

August 27, 2020 – Hurricane Laura. This late-August hurricane attained tropical storm status in the Caribbean and crossed the Florida Keys as a Category 1 storm, then explosively intensified during its passage across the Gulf of Mexico and made landfall in Cameron, Louisiana, as a Category 4 storm on August 27. At the time, it was the strongest hurricane to strike Southwest Louisiana since records began in 1851 (NWS 2020b). The storm moved inland, spawning at least 16 tornadoes in Louisiana, Arkansas, Mississippi, Tennessee, and Alabama. Overall, there were 7 deaths directly attributed to the storm and another 34 indirect deaths from causes such as carbon monoxide poisoning, storm cleanup–related activities, electrocutions, and heat stress (Pasch et al. 2021). Coastal areas of Louisiana and Texas experienced extensive flooding and wind damage to homes, trees, power lines, poles, and industrial facilities, adding up to $19 billion across the United States. In Louisiana and Texas alone, 568,000 households lost power, and nearly 47,000 customers still had no power three weeks later when Hurricane Sally hit the region in mid-September (DOE 2020b).

October 10, 2020 – Hurricane Delta. Only six weeks after Hurricane Laura struck, Hurricane Delta hit Louisiana again, making landfall near the previous site. While a weaker hurricane than Laura, Delta brought significantly more rainfall and flooding, affecting parts of eastern Texas, southern and central Louisiana, and portions of Mississippi and Arkansas. Drainage ditches still clogged by debris from the earlier storm worsened overland flooding, and the outer bands of the storm spawned tornadoes in Mississippi, Alabama, Georgia, and as far as the Carolinas (NWS 2020a). The hurricane caused 6 fatalities, an estimated $2.9 billion in insured damages across the nation, and probably several billion dollars more in uninsured losses (Cangialosi and Berg 2021; Masters 2020). Hundreds of thousands of customers lost power (Baldwin et al. 2020), mostly in Louisiana and some in Texas and Mississippi. Power was also lost to oil and gas production facilities, refineries, and transmission lines (DOE 2020a).

October 29, 2020 – Hurricane Zeta. A couple of weeks later, yet another hurricane made landfall in Louisiana. A fast-moving Category 3 hurricane, Zeta caused most of its damage by wind and less from flooding. As the latest and strongest major hurricane and the sixth to make landfall in the United States in a single year (four of which hit Louisiana), Zeta set many records (Brackett 2020; NWS 2020c). Overall, it caused about $3.9 billion in damages, and due to the extensive wind damage, more than 2.2 million people lost power in the United States (Brackett 2020; Masters 2020). Some 86,000 customers were still out of power five days later (DOE 2020c). The storm's path was nearly identical to that of Hurricane Delta, thus compounding damages and disrupting or even undoing recovery efforts, which further drained private and public financial reserves.

Figure 4. The 2020 Atlantic Hurricane Season’s County-Level Impacts in the MISO+ Region

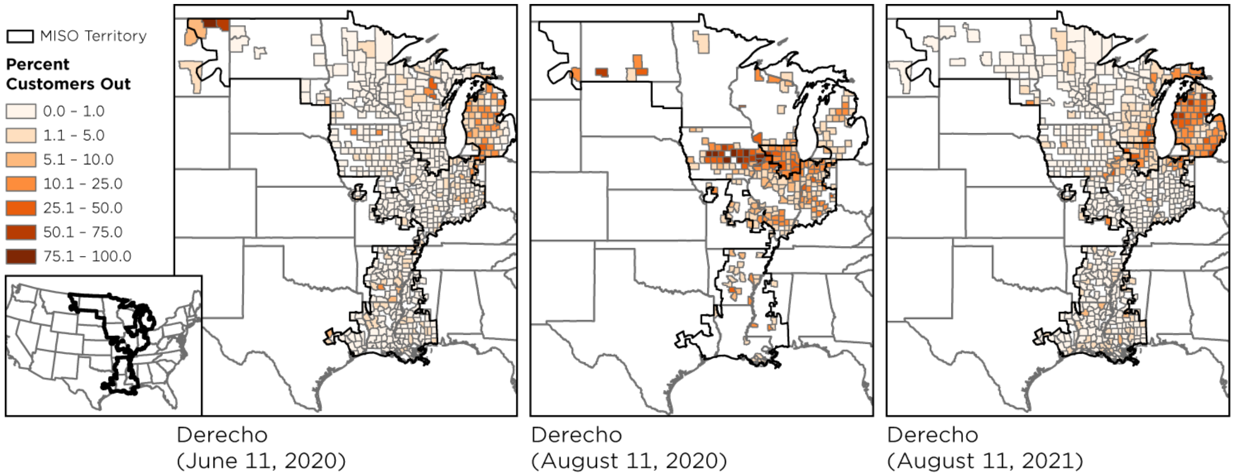


The 2020 Atlantic hurricane season led to three of the 10 worst days across MISO+ between 2014 and 2024 in terms of the peak number of customers affected. Within the span of nine weeks, starting on August 27, 2020, three deadly and catastrophic hurricanes—Hurricanes Laura, Delta, and Zeta—pummeled the state of Louisiana, leaving hundreds of thousands of residents without power in the midst of stifling heat. The back-to-back storms compounded one another, disrupting and even undoing recovery efforts, costing the nation billions of dollars in losses.
SOURCE(S): Brelsford et al. 2024 derived totals.

August 11, 2021 – Derecho. Two rounds of severe thunderstorms swept across a 770-mile swath from southeast South Dakota and northeast Nebraska through Iowa and on to northern Illinois, southern Wisconsin, northern Indiana, southern Michigan, and western Ohio that day. The first brought hurricane-force wind gusts along a long line of high-wind thunderstorms (a derecho); the second was accompanied by intense rain and flash floods. Overall, 2 million customers lost power (Dolce 2021), including 850,000 in Michigan alone (NWS 2021b). Several hundred thousand were out of power for three or more days (WeatherNation 2020). The event was estimated to have caused at least $11.5 billion in damages (Smith 2025).

August 30, 2021 – Hurricane Ida. On August 29, the sixteenth anniversary of Hurricane Katrina, Ida made landfall near Port Fourchon, Louisiana, and devastated Grand Isle (Beven, Hagen, and Berg 2022). The storm had rapidly intensified during its passage across the Gulf of Mexico and made landfall as a Category 4 hurricane but steadily weakened as it moved inland across Louisiana, Mississippi, and onward on a northeasterly path. Along its course, it spawned at least 35 tornadoes and tied for second with Hurricane Laura behind Hurricane Katrina as the most destructive storm to affect Louisiana. The National Oceanic and Atmospheric Administration (NOAA) attributed to the event 55 direct deaths, plus an additional 32 indirect deaths, and estimated a total of $75 billion in damages in the United States, $55 billion in Louisiana alone (Beven, Hagen, and Berg 2022). In Louisiana, more than a million households lost power. A month later, 10 percent of the customers in the most heavily damaged areas along the Gulf Coast were still without power. One news analysis showed that most deaths were due to heat, as people could not get relief through air conditioning (Bogel-Burroughs and Reckdahl 2021).

Figure 5. Summer Derechos' County-Level Impacts in the MISO+ Region



Summer derechos led to three of the 10 worst days across MISO+ between 2014 and 2024 in terms of the peak number of customers affected. Leading up to the 2020 Hurricane Season, two derechos left between 798,000 (June 2020) and 1.64 million (August 2020) people without power. A year later, another derechos left 1.30 million people without power in August 2021.

SOURCE(S): Brelsford et al. 2024 derived totals.

December 16, 2021 – Severe Thunderstorm. A spate of intense thunderstorms caused by a "low pressure system of historic strength" (NWS 2022b) and accompanied by high winds, tornadoes, and wildfires wreaked havoc from the Rocky Mountains to the Great Lakes, with the worst damage reported across Minnesota, Iowa, and Nebraska (Caldwell, Hanna, and Miller 2021). The storms tore off roofs, overturned trucks, shut down interstate highways and air transportation, damaged homes, and injured a small number of people. Hurricane-force gusts brought down power lines, leaving more than 400,000 customers without power across the central United States, mostly in Wisconsin and Michigan. One news report noted, "A tornado in southeastern Minnesota was the first ever reported in the state in the month of December, according to National Oceanic and Atmospheric Administration data. Record heat much farther north than expected this time of year fueled the storms" (Almasy et al. 2021).

August 30, 2022 – Severe Thunderstorm. A line of severe thunderstorms across southern Michigan, with 70 mph winds, caused widespread damage to trees and electric power poles, resulting in extensive power outages (Newman 2022). According to the NWS (2022a), "Peak statewide outages were around 650,000 at one point, making this one of the higher outage-producing severe weather events for the state."

February 23, 2023 – Severe Winter Storm. A harsh, multiday winter storm brought significant icing, strong wind gusts, and heavy snow across a swath from Southern California, through the northern Plains and the Great Lakes region, to the Northeast. Across this region, more than 1 million households lost power. Wisconsin's governor, Tony Evers, declared an "energy emergency" to allow for faster and more efficient restoration of power. In Michigan, where power outages were most extensive, freezing rain and ice had brought down trees and power lines (Massman 2023). The storm system also caused widespread disruptions of air traffic and road transportation (Easter, Fahy, and Oxenden 2023). At the same time these severe winter conditions occurred across the Northern part of the country, some Southern states set numerous heat temperature records (Wolfe, Shackelford, and Sutton 2023).

Cross-Cutting Observations from Recent Weather-Related Outage Events

The review of post-event reports and event-related news articles about these worst weather-related outage events in the MISO+ region yields several cross-cutting observations:

The most damaging events are nearly always caused by compounding disasters. In the 10 worst outage events reviewed, it is never merely a severe thunderstorm or a hurricane alone that leads to these extensive outages. Rather, it is a derecho with multiple tornadoes and wildfires. Or it is a hurricane with tornadoes, coastal and inland flooding, follow-on fires, and extreme heat or damaged industrial facilities causing the accidental release of toxins. Several events coincided with the COVID-19 pandemic, profoundly complicating emergency response, sheltering, and recovery. This has important implications not only for disaster preparedness and emergency response in general (Kruczkiewicz et al. 2021) but for utility operators in particular as they reconsider their plans and responses to complex disasters (Potts et al. 2024).

Mortality from these extreme events is often much higher than reported by official sources. In addition to the direct deaths associated with floods and storms from causes such as drowning or being struck by falling debris, there are many indirect deaths from electrocution, carbon monoxide poisoning (often in winter) or extreme heat (in summer), when electricity for cooking and heating/cooling is offline for extended periods of time. Elevated death rates are being observed for years after such disasters due to the impacts of the added stress, disruptions in health care, lack of infrastructure, poor living conditions, and so on (Young and Hsiang 2024).

Disasters worsen social inequities in multiple, compounding ways. Indirect and post-disaster morbidity and mortality are greater for the more socially vulnerable members of the community (Hahn et al. 2022; Priest and Elliott 2023; Smith et al. 2022). When their homes get damaged, they often do not have anywhere safe to go. The direct disaster effects and long-term stressors during a lengthy recovery period cause more harm to those with preexisting health conditions and lesser economic means than healthy, well-off members of society. And while the worst storms can damage the homes of everyone in affected areas, news reports often point to the devastation caused by high winds and floodwaters, especially to mobile homes, which lack a strong foundation and are built from weaker materials. Mobile homes are, of course, predominantly occupied by lower-income families. Damages to apartment buildings, affecting renters with often limited options to relocate, are also frequently reported. And news reports suggest that areas occupied by lower-income homes, businesses, and renters often have to wait the longest for power to be restored after disruption. Additionally, the wind-dominant events included in our analysis frequently caused extensive damages to crops and farm buildings across the central United States, adding financial losses and burdens to many farmers who already face precarious economic conditions (Bolster et al. 2023; Sievers 2020).

The climate-change drivers underlying these extreme events and resulting in costly outages are rarely discussed in news reports. Nearly all of the 10 worst outage events were associated with high winds, although floods, fire, and ice also contributed substantially to grid system damages. Where high winds dominate, damage to the grid results either from trees falling on power and transmission lines or from winds directly bringing down poles and lines. Their repair and replacement may be among the biggest factors driving recent increases in electricity prices (Frank 2025; Osaka 2025). While news outlets readily report historical records being broken by these weather extremes, the underlying driver that systemically fuels these costly extremes—climate change—is rarely named in the news reports reviewed.

As grid-damaging storms occur more frequently, areas that have experienced damages have little time to rebuild before the next extreme event and therefore are more vulnerable to deeper losses. The 10 worst outage events all happened in the latter five years of the study period, several of them affecting the same areas in the same year (e.g., the record-breaking hurricane season of 2020). This means that people's homes have been covered only by tarps, not solid, new roofs; water-damaged structures have not yet dried out; and dunes have not re-formed, allowing coastal surges to reach deeper inland. Where there is extensive tree damage, urban canopies have not regrown; forest economies are disrupted for years; and poles and power lines have been barely replaced (if at all) and are prone to being damaged again. The results are long-term depletion of people's savings, losses to local economies, heavy financial burdens, disruptions of livelihoods, and long-term health consequences for individuals and families, including the mental health burden of living through repeated traumatic events (Arcaya, Raker, and Waters 2020; Read 2025; Stough and North 2018).

Taken together, our findings reveal that grid resilience has been strained repeatedly over the past decade—with outages again and again followed by repair costs again and again. Who suffers the most from these events is typically those who are most socially vulnerable (Gomberg et al. 2025; Sovacool, Carley, and Kiesling 2024). When extreme events strike, their physical impacts can compound histories of uneven investment, exclusionary planning, and data gaps that obscure who suffers most when power systems fail. Energy justice highlights the intersection of the inequities in housing, health, labor, and socioeconomic geographies that have come to determine whose lights go out first, whose are restored last, and who can cope least with the losses from such outages (Gomberg et al. 2025; Sovacool, Carley, and Kiesling 2024).

In short, strengthening resilience means not only hardening infrastructure but also investing in previously underinvested communities and providing meaningful public engagement opportunities to improve disaster planning and preparedness, response, and recovery. Short of more fundamental rethinking of how to plan the electricity grid for the future and directing resources toward underserved places, the health, well-being, and economic vitality of repeatedly affected communities and regions will continue to be undermined.

As the next section shows, climate change is expected to intensify many aspects of the extreme weather events that drove these catastrophic power outages, heightening physical and social vulnerabilities across the region. The historical record of outages provides a preview of the future: As the climate warms, the same inequities that shaped past disasters risk being amplified by more frequent and severe events.

Climate Change Is Expected to Worsen the Extreme Weather Events That Cause Power Outages

Severe Thunderstorms: Derechos, High Winds, Hail, and Tornadoes

The central United States, where MISO operates, experiences the most severe thunderstorm activity in the country (NSSL n.d.). *Thunderstorm* is an umbrella term that encompasses several types of storms, from ones that rotate and can produce tornadoes to ones with "straight-line winds" that blow in one direction—the most severe of which are called derechos. A severe thunderstorm is one that generates one or more of the following: hail at least one inch in diameter, tornadoes, or wind gusts of at least 57.5 mph. Derechos involve especially large and strong straight-line winds, where the swath of wind damage is at least 240 miles long and wind gusts are at least 58 mph (NSSL n.d.).

Over the last decade, severe thunderstorms have been associated with many of the worst power outages in the MISO+ region. And many aspects of these storms have been on the rise. For example, researchers have estimated that between 1980 and 2020, there has been an approximately 7 percent increase in summertime straight-line winds—as well as a nearly fivefold increase in the area affected by them—in the central United States per degree Fahrenheit of global warming (Climate Central 2025; Prein 2023). There is evidence that tornadoes as well are getting more powerful in the United States (Elsner, Fricker, and Schroder 2019), although researchers have not detected an increase in the overall frequency of these storms (Brooks, Carbin, and Marsh 2014; Gensini and Brooks 2018; Graber, Trapp, and Wang 2024; Tippett, Lepore, and Cohen 2016). There has been a shift, however, in where and when tornadoes most frequently occur. The hotspot of tornado activity has shifted from the Great Plains toward the Midwest and Southeastern United States (Gensini and Brooks 2018; Coleman, Thompson, and Forbes 2024; Graber, Trapp, and Wang 2024; Moore 2025). Tornadoes are occurring more frequently in the cold season (September–February) and less frequently in the warm season (March–August), with a notably large decline (37 percent between 1951 and 2020) during the summer months (Coleman, Thompson, and Forbes 2024).

Moving forward, how thunderstorms are likely to change in response to global warming is still an active area of study, but recent research indicates that many parts of the MISO+ region are projected to experience an increase in both severe thunderstorm activity and length of the severe thunderstorm season as global warming progresses (Ashley, Haberlie, and Gensini 2023; Haberlie et al. 2022; Kaminski et al. 2024). By the end of the century, much of MISO's territory east of the Mississippi River and from Arkansas southward is projected to experience an increase in many forms of severe thunderstorm activity under both moderate- and high-emission scenarios (Ashley, Haberlie, and Gensini 2023; Haberlie et al. 2022; Kaminski et al. 2024).

The number of days with particularly severe thunderstorms capable of producing hail was found to increase across MISO's Midwest territory, especially under a high-emissions scenario, in which much of the region would face at least four additional severe thunderstorm days per year on average, and in many instances, more than a week's worth of such days by the end of the century (Haberlie et al. 2022). The picture is more complex for the northern Great Plains states. Some areas are projected to increase in this class of thunderstorms, whereas others are projected to decrease. In another study, derecho activity was projected to increase across virtually all of the MISO+ territory in a high-emissions scenario, with much of the region projected to experience at least three additional derechos per year on average by the end of the century (Kaminski et al. 2024). Historically, much of MISO+ has experienced up to three derechos per year on average, with areas along the Upper Mississippi River and southern Mississippi River basin experiencing even more (Kaminski et al. 2024).

Several studies project changes in the seasonality of severe thunderstorm activity across the MISO+ territory. Haberlie et al. (2022) projected increases in severe thunderstorm activity in the winter, spring, and fall and decreases in the summer. A study of hail-producing thunderstorms in a high-emissions scenario found that they will start earlier in the year, with more hailstorms in the spring, thus lengthening the hail season (Trapp, Hoogewind, and Lasher-Trapp 2019). The authors projected fewer thunderstorms and therefore less hail during the summer, although the hail that does develop during this season is projected to be larger. The greatest projected increases overall occur in July in the broader northern Great Plains region.

Research specifically focused on how tornadoes are likely to change in a warming world, including how the trends observed to date may progress, is extremely nascent.

Key Takeaways. The projected changes in severe thunderstorm activity are stark across much of the MISO+ region and demand further, more detailed investigation by power system entities in collaboration with climate scientists, given their historical importance for mitigating outages in the region. By the end of the century, much of the MISO+ region east of the Mississippi River and from Arkansas southward is projected to experience an increase in many forms of severe thunderstorm activity under both moderate- and high-emission scenarios. The picture is more complex for the northern Great Plains states, although research points to the likelihood of that region experiencing particularly large increases in hailstorms. Generally, the seasonality of severe thunderstorms is projected to change in a warming world, with increases in storm activity in the spring, fall, and winter months.

Hurricanes

Since the 1980s, hurricanes, once formed, have been gathering strength faster in the Atlantic basin as a result of human-caused climate change (Bhatia et al. 2019; Marvel et al. 2023). The amount of precipitation that hurricanes are bringing is also increasing across much of the MISO+ area affected by hurricanes (Shearer et al. 2022; Uehling and Schreck 2024). How climate change has affected the historical frequency of hurricanes is currently an active area of research (Vecchi et al. 2021).

Over the last decade, however, climate science has made considerable advancements in quantifying the influence of human-caused climate change on individual hurricanes and hurricane seasons. For instance, Reed, Wehner, and Zarzycki (2022) determined that human-caused climate change increased the amount of extreme rainfall received during the 2020 hurricane season (whose Hurricanes Laura, Delta, and Zeta all contributed to major power outages within MISO's territory). In another study, researchers estimated that human-caused climate change increased Hurricane Harvey's precipitation intensity by 15 percent and made the record-setting storm, which brought nearly four feet of rain to some locations, approximately three times more likely to occur (Kunkel and Champion 2019; van Oldenborgh et al. 2017).

Looking forward, there is evidence of a likely increase in the rate of precipitation from hurricanes making landfall in the United States (Knutson et al. 2022) as has already been observed (Shearer et al. 2022; Uehling and Schreck 2024). Also, recent research indicates that there may be an increase in the number of major hurricanes that make landfall in the United States (Knutson et al. 2022), as well as an increase in the intensity of hurricanes that form as global warming progresses (Knutson et al. 2020). As with research focused on the past, the question of whether the frequency of hurricanes will increase in the Atlantic basin in the future as a result of human-caused climate change is an active area of research (Knutson et al. 2022; Marvel et al. 2023). In a study by the Electric Power Research Institute and the Pacific Northwest National Laboratory, the authors found that by the end of the century, under a high-emissions scenario, much of the coastal region within MISO's territory will experience approximately one additional severe power outage per decade as a result of global warming–induced changes in hurricane activity (EPRI 2024).

Key Takeaways. While it is still unclear whether the number of hurricanes will increase within the MISO+ region as a result of human-caused climate change, the research is clear that the region's hurricanes are intensifying more rapidly and carrying more extreme precipitation, a trend expected to persist as global warming continues. A collaboration between power system actors and climate scientists in regions susceptible to hurricanes—including inland areas—will be important for decisionmaking informed by the latest developments in scientific understanding in this arena.

Extreme Winter Storms

Across much of MISO's territory, winter is warming faster than summer and the length of the cold season is decreasing (Marvel et al. 2023). As global warming progresses, the period when snowstorms occur is expected to decrease, with fewer snowstorms occurring early and late in the snow season (Ashley et al. 2025; Notaro et al. 2014). Many studies point to the likelihood of less snowfall overall and a northward shift in the boundary of where snow occurs (Ashley et al. 2025; Ning and Bradley 2015).

There is still considerable uncertainty, however, around how the frequency of extreme snowfall events are likely to change in a warming world in the central United States. Some studies suggest a decrease in the number of severe snowstorms (Browne and Chen 2023), while others raise the possibility of decreases in extreme snowfall events along and south of the Ohio River Valley and increases in these events to the north of this region (Ashley et al. 2025). Winter storms that do form in the future might be more intense for a few reasons (Ashley et al. 2025; Notaro et al. 2014). First, a warming atmosphere can hold more moisture that can then fall as snow under the right conditions (Ashley et al. 2025). Second, there may be more extratropical cyclones in parts of the central United States—for example, the Upper Midwest—that can produce winter storms (Eichler 2020).

Furthermore, researchers have identified a link between severe winter weather in the Northern United States and Arctic warming (Agel et al. 2025; Cohen, Francis, and Pfeiffer 2024). As the Arctic warms, it can affect the northern polar vortex—an area of low pressure and cold air that circulates at the Earth's northern pole (NWS n.d.)—causing southward dips in the jet stream that can bring persistent periods of extremely cold weather, as was seen during Winter Storm Uri (Cohen et al. 2021). The dynamics of these relationships, including how they will develop in the future, is an active area of research, with researchers raising the possibility that these kinds of events could bring extreme winter weather to regions unaccustomed to such cold outbreaks (Hanna et al. 2024).

Key Takeaways. The length of the cold season and the period when snowstorms occur are shrinking. These trends are expected to continue into the future as the world warms. There is also likely to be a northward shift in the boundary of where snow falls, resulting in decreases in snowfall in some portions of MISO+. However, it is possible that snowstorms may become more intense in the places where they continue to occur, and a warming Arctic may bring periods of severe winter weather to the MISO+ region, including places not typically accustomed to such weather. For these reasons, power system actors must collaborate with climate scientists to keep abreast of scientific developments that consider the need to prepare for future Uri-like winter storms.

Grid Planning and Investment Decisions Need to Ensure Grid Resilience

The research presented here begins to answer some of the core questions for decisionmakers and other entities involved in the MISO+ region seeking to ensure a more resilient, equitable electric grid: which types of extreme weather events have caused the most widespread and/or prolonged power outages, who has been impacted in the recent past during major weather-related outages, and how climate change is expected to alter the frequency, seasonality, and severity of these events.

As states, utilities, and MISO prepare for immediate responses to extreme weather—for example, by developing protocols and practices for how to react in real time when extreme weather hits—they must also plan and invest in a more resilient grid. This involves assessing future risks and developing grid investment strategies to mitigate those risks well in advance of projected extreme weather. Although MISO and many utilities and states point to robust preparation for extreme weather, they have taken a largely piecemeal and inadequate approach in planning and investing for future grid resilience needs across the MISO+ region.

As of January 2025, only two states in the region, Michigan and Texas, along with the city of New Orleans, specifically require utilities to file resilience plans with the respective regulatory commissions that have oversight over utility investments (Collins et al. 2025). Other states in MISO+, including Iowa, have recently opened dockets seeking information on how utilities are preparing for or addressing extreme weather risks (IUC 2025). Most states, however, have left climate resilience planning and investing largely to local jurisdictions and their communities. Local climate action plans are indeed important, but local jurisdictions rarely have regulatory oversight over utilities. Without this, such plans relegate communities largely to merely surviving widespread or extended power outages rather than ensuring that outages are prevented in the first place.

At MISO, which bears the responsibility for long-term, system-wide transmission planning and investment decisions, the value of new transmission system infrastructure in avoiding power outages during extreme weather has only recently entered the picture as a formal consideration in the decisionmaking process (MISO 2024). MISO's approach considers the value of avoided outages during a single type of event—a hypothetical winter storm—when calculating whether the benefits of a proposed transmission investment outweigh the costs and therefore should be approved for construction. This benefit metric complements several other benefit metrics developed by MISO to capture the multivalue nature of transmission investments. While a step in the right direction, this approach falls short of robust resilience planning that includes a more comprehensive and proactive risk assessment process to identify grid investments under different future climate scenarios that specifically help mitigate the impacts identified across multiple extreme weather events.

Recommendations

Based on our analysis, we offer this brief set of recommendations. It adds to and lifts key needs from the UCS report Keeping Everyone's Lights On (Gomberg et al. 2025). If implemented, these recommendations can set us on a path toward a more equitable and resilient grid that is prepared to serve communities in the face of climate change and extreme weather risk.

Understand the risks posed by extreme weather and climate change. While this study provides a broad sketch of some of the key climate risks likely to affect the region, we emphasize that states, utilities, and MISO should complete fine-scale, comprehensive climate risks assessments. Such assessments should examine the full suite of extreme weather risks facing the region over the next thirty to fifty years and beyond. Climate risk assessments should (1) take advantage of the best-available climate science regarding extreme weather risks and patterns over time, (2) seek to identify specific areas of investment needs to bolster resilience, (3) involve input and ownership from the communities served by the grid, and (4) include concrete next steps to begin addressing identified risks in a holistic, inclusive, and cost-effective way.

Accelerate the clean energy transition. Despite a current lack of federal leadership, states and utilities must continue to reduce planet-warming emissions to lessen the risks associated with ever-worsening extreme weather. The quicker that society can decarbonize, the less intense the impacts of climate change and extreme weather will be.

Engage with communities. States and MISO should ensure that grid investments made to build resilience (1) are informed by community input, (2) are complementary to community-level initiatives, and (3) do not displace risk from one vulnerable community to another without mitigating the risk or strengthening community resilience. Deliberate and transparent engagement with communities, particularly those most vulnerable to the impacts of power outages, help ensure that investment decisions better account for adaptation needs to prolonged outages during and after extreme weather events. Case studies demonstrate that transmission projects developed through genuine partnership with communities, including applying clear community benefits frameworks rather than one-way engagement, experience fewer delays, have stronger local support, and result in more durable resilience gains for communities (Kurland et al. 2025).

Be proactive, not reactive. There is always uncertainty in projecting the future. Still, we cannot let this uncertainty lead to inaction. While historical experience is a vital piece of understanding how to move forward, decisions must be primarily informed by our best understanding of potential future conditions. States, utilities, and MISO must ultimately take action on developing and implementing the climate risk assessments recommended previously. At the state and utility levels, this means opening new regulatory dockets that invite input from communities and other involved parties to decide how to move forward in addressing the identified climate risks to customers and communities. At the MISO level, it means developing new methodologies that accurately reflect the full suite of risks facing the system and that capture the full range of benefits from transmission system investments that mitigate those risks.

Defend government science services. Federal and state agencies provide much of the scientific data necessary to understand weather patterns, climate change trends and impacts, and, ultimately, the risks posed by extreme weather in both near-term and long-term forecasts. For example, MISO relies on essential real-time weather and climate variability information from NOAA's Weather Prediction Center and Climate Prediction Center (MISO n.d.). Private sector climate services are all dependent on such underlying information being available. Unfortunately, much of this critical work is under threat from politicians and special interests that either do not recognize the value of science or directly benefit from the suppression of climate science (Minovi et al. 2025). States, utilities, and RTOs that are ultimately responsible for keeping the lights on must be vocal in expressing the importance of government-sponsored data collection and dissemination, as well as scientific research that can help us understand what future conditions to expect and how to effectively prepare for them.

Hold utilities and MISO accountable. States are key players in building a more resilient electric grid because they are uniquely situated to hold both utilities and MISO accountable for responsible, climate-informed resilience planning and investment. Extreme weather events can no longer be shrugged away as system anomalies that we cannot foresee or plan for. Recent events and ongoing climate research are telling us we need to act and that failure to do so is negligent. States can hold their local utilities accountable through new legislation and regulatory requirements specifically articulating climate resilience as an obligation. Once a legal obligation has been established, creating mechanisms and metrics for monitoring, accountability, and trust is critical to ensure that grid investments build resilience cost-effectively and equitably (Kurland et al. 2025; Rokstad 2025; Webb, Panfil, and Ladin 2020).

Because extreme weather events do not respect state or utility boundaries, MISO is also a critical actor in grid resilience efforts. The RTO's system-wide perspective and ability to coordinate interstate efforts makes it well positioned to identify broadly beneficial solutions to grid resilience issues. Holding MISO accountable involves both state and federal jurisdiction. The Federal Energy Regulatory Commission (FERC) has authority over RTOs like MISO to require their more robust consideration of future climate change and extreme weather risks when identifying system needs and making transmission system investments. States also have significant influence over MISO because any transmission investment approved by MISO must also be approved through state regulatory processes. Using this leverage, states should hold MISO accountable by demanding better climate resilience planning, scrutinizing MISO-approved transmission projects in the context of grid resilience, and seeking federal intervention if MISO is not responsive to these efforts.

Conclusion

In our review of a decade of weather-related outages in the central United States, we found that all of the region's one hundred worst outage days, measured in maximum number of customers affected, were associated with a large-scale extreme weather event. Moreover, all of the 10 worst outage days have occurred since 2020. What is particularly troubling is that the largest power outages were nearly always caused by compounding events, such as a winter storm with a tornado outbreak or a hurricane with coastal and inland flooding. Several of the events occurred back-to-back, implicating the same communities over a short period of time and leaving households and communities little time for recovery. Such damaging events deepen social inequities.

The previous decade is a preview of the coming years: As the climate warms, many extreme weather events are expected to become both more frequent and more severe. Without intentional and proactive investments, the same inequities that have shaped the differential impacts of recent events will be amplified in marginalized and underserved communities. As we named previously in Keeping the Lights On, the growing risk of compound events necessitates smart investments that build resilience against the myriad and interrelated risks to everyone. Investing in grid resilience is thus inseparable from investing in energy justice so that the communities historically least prepared to withstand and recover from extreme events are not left behind as decisionmakers modernize the grid.

Power system actors at all levels have a role to play in building grid resilience. Local utilities, states, regional grid operators, and federal regulators each have distinct responsibilities in the task. To best prepare the region's power grid for climate change and safeguard the communities affected by outages, at minimum, we need to understand better the risks posed by extreme weather and climate change, accelerate the transition to an electricity grid powered by clean energy, and ensure the inclusion of communities in decisionmaking processes.

Authors

Rachel Licker, PhD, is the principal of Connected Science, LLC. **Susanne Moser**, PhD, is the director of Susanne Moser Research & Consulting and a research scholar at Antioch University New England. **Sam Gomberg** is an associate director for transmission policy in the Climate and Energy Program at the Union of Concerned Scientists. **Amanda Fencl**, PhD, is the director for climate science in the program. **Sital Sathia** is a research officer for energy justice research and policy in the program. **Jayson Toweh** was a 2025 Schneider Summer Fellow in the program.

Acknowledgments

For their feedback, the authors thank our external reviewers, Natalie McIntire (Natural Resources Defense Council) and Ciaran Gallagher (Clean Wisconsin), and our UCS colleagues, Jeff Deyette, Carlos Martinez, John Rogers, Mark Specht, and Erika Spanger. We are also grateful to our colleagues Colin Byers, Deanna Celi, James Gignac, L. Delta Merner, John Rogers, Kyle Ann Sebastian, Eric Schulz, Daela Taeoalii-Tipton, Heather Tuttle, and Bryan Wadsworth, and to Dana Johnson for her expert editing.

Organizational affiliations are listed for identification purposes only. The opinions expressed herein do not necessarily reflect those of the organizations that funded the work or the individuals who reviewed it. The authors bear sole responsibility for the report's content.

References

Agar, John. 2020. "Power Outages, Damage Reported in West Michigan After Overnight Thunderstorm." *MLive*, June 10. https://www.mlive.com/news/kalamazoo/2020/06/power-outages-damage-reported-in-west-michigan-after-overnight-thunderstorm.html.

Agel, Laurie, Judah Cohen, Mathew Barlow, Karl Pfeiffer, Jennifer Francis, Chaim I. Garfinkel, and Marlene Kretschmer. 2025. "Cold-Air Outbreaks in the Continental US: Connections with Stratospheric Variations." *Science Advances* 11 (28): eadq9557. https://doi.org/10.1126/sciadv.adq9557.

Aldhous, Peter, Stephanie M. Lee, and Zahra Hirji. 2021. "The Texas Winter Storm and Power Outages Killed Hundreds More People Than the State Says." *BuzzFeed News*, May 26. https://www.buzzfeednews.com/article/peteraldhous/texas-winter-storm-power-outage-death-toll.

Almasy, Steve, Brandon Miller, Amy Simonson, and Amanda Watts. 2021. "Intense Storm Spawns Tornadoes, Including First Ever Observed in Minnesota During December." *CNN*, December 16. https://www.cnn.com/2021/12/15/weather/us-weather-wednesday.

Arbaje, Paul, and Mark Specht. 2024. *Gas Malfunction: Calling into Question the Reliability of Gas Power Plants*. Union of Concerned Scientists. https://doi.org/10.47923/2024.15312.

Arcaya, Mariana, Ethan J. Raker, and Mary C. Waters. 2020. "The Social Consequences of Disasters: Individual and Community Change." *Annual Review of Sociology* 46:671–91. https://doi.org/10.1146/annurev-soc-121919-054827.

Ashley, Walker S., Alex M. Haberlie, and Vittorio A. Gensini. 2023. "The Future of Supercells in the United States." *Bulletin of the American Meteorological Society* 104 (1): E1–E21. https://doi.org/10.1175/BAMS-D-22-0027.1.

Ashley, Walker S., Aaron Zeeb, Alex M. Haberlie, Vittorio A. Gensini, and Allison Michaelis. 2025. "The Future of Snowstorms in Central and Eastern North America." *International Journal of Climatology* 45 (6): e8770. https://doi.org/10.1002/joc.8770.

Baldwin, Sarah Lynch, Victoria Albert, Jordan Freiman, Justin Bey, and Zoe Christen Jones. 2020. "Hurricane Delta Leaves Hundreds of Thousands Without Power." *CBS News*, October 11. https://www.cbsnews.com/live-updates/hurricane-delta-power-outages/.

Beven, John L., II, Andrew Hagen, and Robbie Berg. 2022. *National Hurricane Center Tropical Cyclone Report: Hurricane Ida*. NHC AL092021. National Oceanic and Atmospheric Administration. https://www.nhc.noaa.gov/data/tcr/AL092021_Ida.pdf.

Bhatia, Kieran T., Gabriel A. Vecchi, Thomas R. Knutson, Hiroyuki Murakami, James Kossin, Keith W. Dixon, and Carolyn E. Whitlock. 2019. "Recent Increases in Tropical Cyclone Intensification Rates." *Nature Communications* 10 (1): 635. https://doi.org/10.1038/s41467-019-08471-z.

Bogel-Burroughs, Nicholas, and Katy Reckdahl. 2021. "The Greatest Killer in New Orleans Wasn't the Hurricane. It Was the Heat." *New York Times*, September 15. https://www.nytimes.com/2021/09/15/us/new-orleans-hurricane-ida-heat.html.

Bolster, Carl H., Rob Mitchell, Andrew Kitts, Amber Campbell. Michael Cosh, Tracey L. Farrigan, Alan J. Franzluebbers et al. 2023. "11. Agriculture, Food Systems, and Rural Communities." In *Fifth National Climate Assessment*, edited by A. R. Crimmins, C. W. Avery, D. R. Easterling, K. E. Kunkel, B. C. Stewart, and T. K. Maycock. U.S. Global Change Research Program. https://nca5.climate.us/chapter/11.

Brackett, Ron. 2020. "Zeta Leaves 6 People Dead, Millions in the Dark." *Weather Channel*, October 30. https://weather.com/news/news/2020-10-29-hurricane-zeta-impacts-louisiana-mississippi-alabama-georgia-carolinas.

Brelsford, Christa, Sarah Tennille, Aaron Myers, Supriya Chinthavali, Varisara Tansakul, Matthew Denman, Mark Coletti et al. 2024. "A Dataset of Recorded Electricity Outages by United States County 2014–2022." *Scientific Data* 11 (1): 271. https://doi.org/10.1038/s41597-024-03095-5.

Brooks, Harold E., Gregory W. Carbin, and Patrick T. Marsh. 2014. "Increased Variability of Tornado Occurrence in the United States." *Science* 346 (6207): 349–52. https://doi.org/10.1126/science.1257460.

Browne, Ahmani, and Liang Chen. 2023. "Investigating the Occurrence of Blizzard Events over the Contiguous United States Using Observations and Climate Projections." *Environmental Research Letters* 18 (11): 114044. https://doi.org/10.1088/1748-9326/ad0449.

Caldwell, Travis, Jason Hanna, and Brandon Miller. 2021. "More than 400K Have No Power Across the Central US After Storms Delivered Record Spate of Hurricane-Force Gusts." *CNN*, December 16. https://www.cnn.com/2021/12/16/weather/extreme-weather-central-us-thursday.

Cangialosi, John. P., and Robbie Berg. 2021. *National Hurricane Center Tropical Cyclone Report: Hurricane Delta*. NHC AL262020. National Oceanic and Atmospheric Administration. https://www.nhc.noaa.gov/data/tcr/AL262020_Delta.pdf.

Childs, Jan Wesner. 2020. "Hundreds of Thousands Without Power After High Winds Scour Michigan, Indiana, Ohio, Kentucky, Pennsylvania." *Weather Channel*, June 11. https://weather.com/news/news/2020-06-10-midwest-winds-storms-rain-indiana-michigan-ohio-power-outages.

Climate Central. 2020. "Power Off: Extreme Weather and Power Outages." September 30. https://www.climatecentral.org/climate-matters/power-outages.

———. 2024. "Weather-Related Power Outages Rising." April 24. https://www.climatecentral.org/climate-matters/weather-related-power-outages-rising.

———. 2025. "Thunderstorm Straight-Line Winds." August 13. https://www.climatecentral.org/climate-matters/thunderstorm-winds-2025.

Cohen, Judah, Laurie Agel, Mathew Barlow, Chaim I. Garfinkel, and Ian White. 2021. "Linking Arctic Variability and Change with Extreme Winter Weather in the United States." *Science* 373 (6559): 1116–21. https://doi.org/10.1126/science.abi9167.

Cohen, Judah, Jennifer A. Francis, and Karl Pfeiffer. 2024. "Anomalous Arctic Warming Linked with Severe Winter Weather in Northern Hemisphere Continents." *Communications Earth & Environment* 5 (1): 557. https://doi.org/10.1038/s43247-024-01720-0.

Coleman, Timothy A., Richard L. Thompson, and Gregory S. Forbes. 2024. "A Comprehensive Analysis of the Spatial and Seasonal Shifts in Tornado Activity in the United States." *Journal of Applied Meteorology and Climatology* 63 (6): 717–30. https://doi.org/10.1175/JAMC-D-23-0143.1.

Collins, Myles, Matia Whiting, Josh Schellenberg, and Lisa Schwartz. 2025. *Bridging the Gap on Data, Metrics, and Analyses for Grid Resilience to Weather Events: Information That Utilities Can Provide Regulators, State Energy Offices and Other Stakeholders*. Lawrence Berkeley National Laboratory. https://eta-publications.lbl.gov/sites/default/files/2025-

01/bridging_the_gap_resilience_data_metrics_and_analysis_final.pdf.
DOE (Department of Energy). 2020a. *Hurricane Delta | Update #4 - FINAL*. https://www.energy.gov/sites/prod/files/2020/10/f79/TLP-WHITE_DOE%20Situation%20Update_Delta_4_FINAL_1.pdf.
———. 2020b. *Hurricanes Laura and Sally | Update #22*. https://www.energy.gov/ceser/articles/combined-report-hurricanes-sally-laura-9182020.
———. 2020c. *Hurricane Zeta | Update #6 - FINAL*. https://www.energy.gov/sites/default/files/2020/11/f80/TLP-WHITE_DOE%20Situation%20Update%20%236_Zeta_FINAL.pdf.
Dolce, Chris. 2021. "$11.5B in Damage in 14 Hours: Derecho Ripped Across the Midwest One Year Ago." *Weather Underground*, August 9. https://www.wunderground.com/article/storms/severe/news/2021-08-09-midwest-iowa-derecho-august-2020-anniversary.
Easter, Sam, Claire Fahy, and McKenna Oxenden. 2023. "'Frustrating and Upsetting': Residents in Michigan Endure Fifth Day Without Power." *New York Times*, February 26. https://www.nytimes.com/2023/02/25/us/michigan-winter-storm-power-outage.html.
EIA (Energy Information Administration). 2025. Energy Atlas RTO Regions. https://atlas.eia.gov/datasets/eia::rto-regions/about. Accessed August 27, 2025.
Eichler, Timothy Paul. 2020. "The Impacts of a Warming Climate on Winter Mid-latitude Cyclones in the NARCCAP Model Suite." *Climate Dynamics* 54 (9): 4379–98. https://doi.org/10.1007/s00382-020-05236-z.
Elsner, James B., Tyler Fricker, and Zoe Schroder. 2019. "Increasingly Powerful Tornadoes in the United States." *Geophysical Research Letters* 46 (1): 392–98. https://doi.org/10.1029/2018GL080819.
EPRI (Electric Power Research Institute). 2024. "Climate READi: Projected Changes in Hurricane-Induced Power Outages in a Future Climate." July. http://view.ceros.com/epri/readi-storymap.
Erdman, Jonathan. 2020. "A Derecho, a Widespread Destructive Thunderstorm Wind Event, Swept Across Michigan, Indiana, Ohio, Wednesday." *Weather Channel*, June 12. https://weather.com/storms/severe/news/2020-06-10-midwest-derecho-michigan-ohio-indiana.
Fant, Charles, Brent Boehlert, Kenneth Strzepek, Peter Larsen, Alisa White, Sahil Gulati, Yue Li, and Jeremy Matinich. 2020. "Climate Change Impacts and Costs to U.S. Electricity Transmission and Distribution Infrastructure." *Energy* 195 (March): 116899. https://doi.org/10.1016/j.energy.2020.116899.
Frank, Thomas. 2025. "Electricity Prices Jump After Trump Rejects Disaster Aid for Michigan Utilities." *Politico*, November 30. https://www.politico.com/news/2025/11/30/electricity-prices-jump-after-trump-rejects-disaster-aid-for-michigan-utilities-00665572.
Gensini, Vittorio A., and Harold E. Brooks. 2018. "Spatial Trends in United States Tornado Frequency." *npj Climate and Atmospheric Science* 1 (1): 38. https://doi.org/10.1038/s41612-018-0048-2.
Goggin, Michael. 2021. *Transmission Makes the Power System Resilient to Extreme Weather*. Grid Strategies LLC and American Council on Renewable Energy. https://acore.org/wp-content/uploads/2021/07/GS_Resilient-Transmission_proof.pdf.
Goggin, Michael, and Jesse Schneider. 2022. *The One-Year Anniversary of Winter Storm Uri: Lessons Learned and the Continued Need for Large-Scale Transmission.* Grid Strategies LLC. https://gridstrategiesllc.com/wp-content/uploads/2024/05/the-one-year-anniversary-of-winter-storm-uri-lessons-learned-and-the-continued-need-for-large-scale-transmission.pdf.
Gomberg, Sam, Rachel Licker, Sital Sathia, and Pamela Worth. 2025. *Keeping Everyone's Lights On: How to Build an Equitable, Climate-Resilient Power Grid*. Union of Concerned Scientists. https://doi.org/10.47923/2025.15855.
Graber, Matthew, Robert J. Trapp, and Zhuo Wang. 2024. "The Regionality and Seasonality of Tornado Trends in the United States." *npj Climate and Atmospheric Science* 7 (1): 144. https://doi.org/10.1038/s41612-024-00698-y.
Haberlie, Alex M., Walker S. Ashley, Christopher M. Battisto, and Vittorio A. Gensini. 2022. "Thunderstorm Activity Under Intermediate and Extreme Climate Change Scenarios." *Geophysical Research Letters* 49 (14): e2022GL098779. https://doi.org/10.1029/2022GL098779.
Haddad, Ken. 2020. "Tracking DTE Power Outages in SE Michigan on June 10, 2020." *ClickOnDetroit*,

June 10. https://www.clickondetroit.com/news/local/2020/06/10/tracking-dte-power-outages-in-se-michigan-on-june-10-2020/.

Hahn, Micah B., Rebecca Van Wyck, Lauren Lessard, and Ruby Fried. 2022. "Compounding Effects of Social Vulnerability and Recurring Natural Disasters on Mental and Physical Health." *Disaster Medicine and Public Health Preparedness* 16 (3): 1013–21. https://doi.org/10.1017/dmp.2020.476.

Hanna, Edward, Jennifer Francis, Muyin Wang, James E. Overland, Judah Cohen, Dehai Luo, Timo Vihma et al. 2024. "Influence of High-Latitude Blocking and the Northern Stratospheric Polar Vortex on Cold-Air Outbreaks Under Arctic Amplification of Global Warming." *Environmental Research: Climate* 3 (4): 042004. https://doi.org/10.1088/2752-5295/ad93f3.

IDNR (Iowa Department of Natural Resources). 2025. "5 Years of Derecho Recovery." ArcGIS StoryMaps, July 18. https://storymaps.arcgis.com/stories/ba98113395d34a03a1b8bd348418bf2c.

Irwin, Lauren. 2024. "Texas Appeals Court Says Winter Storm Lawsuits Against Transmission and Distribution Utilities Can Move Forward." *The Hill*, April 3. https://thehill.com/regulation/court-battles/4573473-texas-appeals-court-says-winter-storm-lawsuits-against-transmission-and-distribution-utilities-can-move-forward/ Snyder.

IUC (Iowa Utilities Commission). 2025. "IUC Requests Information from Rate-Regulated Electric Utilities on 2025 Summer Preparedness, Grid Resilience Plans." Press release, April 25. https://iuc.iowa.gov/press-release/2025-04-25/iuc-requests-information-rate-regulated-electric-utilities-2025-summer-preparedness-grid-resilience.

Kaminski, Kristie, Walker S. Ashley, Alex M. Haberlie, and Vittorio A. Gensini. 2024. "Future Derecho Potential in the United States." *Journal of Climate* 38 (1): 3–26. https://doi.org/10.1175/JCLI-D-23-0633.1.

Knutson, Thomas, Suzana J. Camargo, Johnny C. L. Chan, Kerry Emanuel, Chang-Hoi Ho, James Kossin, Mrutyunjay Mohapatra et al. 2020. "Tropical Cyclones and Climate Change Assessment: Part II: Projected Response to Anthropogenic Warming." *Bulletin of the American Meteorological Society* 101 (3): E303–E22. https://doi.org/10.1175/BAMS-D-18-0194.1.

Knutson, Thomas R., Joseph J. Sirutis, Morris A. Bender, Robert E. Tuleya, and Benjamin A. Schenkel. 2022. "Dynamical Downscaling Projections of Late Twenty-First-Century U.S. Landfalling Hurricane Activity." *Climatic Change* 171 (3–4): 28. https://doi.org/10.1007/s10584-022-03346-7.

Kruczkiewicz, A., J. Klopp, J. Fisher, S. Mason, S. McClain, N. M. Sheekh, R. Moss, R. M. Parks, and C. Braneon. 2021. "Compound Risks and Complex Emergencies Require New Approaches to Preparedness." *Proceedings of the National Academy of Sciences* 118 (19): e2106795118. https://doi.org/10.1073/pnas.2106795118.

Kunkel, Kenneth E., and Sarah M. Champion. 2019. "An Assessment of Rainfall from Hurricanes Harvey and Florence Relative to Other Extremely Wet Storms in the United States." *Geophysical Research Letters* 46 (22): 13500–13506. https://doi.org/10.1029/2019GL085034.

Kurland, Adam, Nicole Pavia, Natalie Manitius, and Kelsey Landau. 2025. *Beyond the Wires: Lessons from Transmission Lines Built with Community Benefits*. Environmental Defense Fund and Clean Air Task Force. https://library.edf.org/AssetLink/5oo47j6cy1jrc131hjm3i8140u0ak26j.pdf.

Marvel, Kate, Wenying Su, Roberto Delgado, Sarah Aarons, Abhishek Chatterjee, Margaret E. Garcia, Zeke Hausfather et al. 2023. "2. Climate Trends." In *Fifth National Climate Assessment*, edited by A. R. Crimmins, C. W. Avery, D. R. Easterling, K. E. Kunkel, B. C. Stewart, and T. K. Maycock. U.S. Global Change Research Program. https://nca5.climate.us/chapter/2.

Massman, Bradley. 2023. "Days After Ice Storm, Nearly 210,000 in Michigan Still Without Power." *MLive*, February 26. https://www.mlive.com/news/2023/02/days-after-ice-storm-nearly-210000-in-michigan-still-without-power.html.

Masters, Jeff. 2020. "Hurricane Zeta's High Winds Cause Second Largest U.S. Power Outage of 2020." *Yale Climate Connections*, October 29. https://yaleclimateconnections.org/2020/10/hurricane-zetas-high-winds-cause-largest-u-s-power-outage-of-2020/.

Minovi, Darya, Jules Barbati-Dajches, Rachel Cleetus, and Kristie Ellickson. 2025. *Science and Democracy Under Siege: Documenting Six Months of the Trump Administration's Destructive Actions*. Union of Concerned Scientists. https://www.ucs.org/resources/science-and-democracy-under-siege.

MISO (Midcontinent Independent System Operator). 2024. *LRTP Tranche 2 Benefit Metrics Development: Energy Savings from Reduced Losses, Reduced Risks from Extreme Weather Impacts, and Mitigation of Reliability Issues*.

https://cdn.misoenergy.org/20240426%20LRTP%20Workshop%20Item%2002%20Business%20Case%20Metrics%20Development632634.pdf.

———. n.d. *The February Arctic Event: February 14–18, 2021: Event Details, Lessons Learned and Implications for MISO's Reliability Imperative.* https://cdn.misoenergy.org/2021%20Arctic%20Event%20Report554429.pdf.

Moore, Todd W. 2025. "Targeted Decomposition of Tornado Records Reveals Long-Term Trends in the Great Plains and Southeast United States." *Scientific Reports* 15 (1): 36940. https://doi.org/10.1038/s41598-025-20868-z.

NCEI (National Centers for Environmental Information). 2020. "Monthly National Climate Report for June 2020". National Oceanic and Atmospheric Administration. https://www.ncei.noaa.gov/access/monitoring/monthly-report/national/202006.

Newman, Eli. 2022. "Storms Leave Hundreds of Thousands of Michiganders Without Power." *Michigan Public*, August 30. https://www.michiganpublic.org/public-safety/2022-08-30/storms-leave-hundreds-of-thousands-of-michiganders-without-power.

Ning, Liang, and Raymond S. Bradley. 2015. "Snow Occurrence Changes over the Central and Eastern United States Under Future Warming Scenarios." *Scientific Reports* 5 (1): 17073. https://doi.org/10.1038/srep17073.

Notaro, Michael, David Lorenz, Christopher Hoving, and Michael Schummer. 2014. "Twenty-First-Century Projections of Snowfall and Winter Severity Across Central-Eastern North America." *Journal of Climate* 27 (17): 6526–50. https://doi.org/10.1175/JCLI-D-13-00520.1.

NSSL (National Severe Storms Laboratory). n.d. "Thunderstorm Basics." National Oceanic and Atmospheric Administration. https://www.nssl.noaa.gov/education/svrwx101/thunderstorms/.

NWS (National Weather Service). 2020a. "Hurricane Delta 2020." October. National Oceanic and Atmospheric Administration. https://www.weather.gov/lch/2020delta.

———. 2020b. "Hurricane Laura 2020." August. National Oceanic and Atmospheric Administration. https://www.weather.gov/lch/2020Laura.

———. 2020c. "Hurricane Zeta 2020." October. National Oceanic and Atmospheric Administration. https://www.weather.gov/lch/2020Zeta.

———. 2020d. "June 9–10, 2020: Gusty Wind-Producing Showers; Brief Tornado near Onarga, IL. Morning Wind Damage on the 10th." June. National Oceanic and Atmospheric Administration. https://www.weather.gov/lot/09june2020.

———. 2020e. "June 10, 2020 Severe Weather." June. National Oceanic and Atmospheric Administration. https://www.weather.gov/grr/10June2020SevereWeather.

———. 2020f. "Severe Thunderstorm Summary 6-10-2020." June. National Oceanic and Atmospheric Administration. https://www.weather.gov/dtx/SevereThunderstorms-06-10-2020.

———. 2021a. "August 10, 2020, Midwest Derecho." ArcGIS StoryMaps, August 6. National Oceanic and Atmospheric Administration. https://storymaps.arcgis.com/stories/f98352e2153b4865b99ba53b86021b65.

———. 2021b. "Severe Thunderstorm and Heavy Rainfall Summary August 11–12, 2021." National Oceanic and Atmospheric Administration. https://www.weather.gov/dtx/SevereThunderstorms-August-11-12-2021.

———. 2021c. "Valentine's Week Winter Outbreak 2021: Snow, Ice, & Record Cold." National Oceanic and Atmospheric Administration. https://www.weather.gov/hgx/2021ValentineStorm.

———. 2022a. "August 29, 2022 Squall Line." National Oceanic and Atmospheric Administration. https://www.weather.gov/grr/29Aug2022SquallLine.

———. 2022b. "Historic, Unprecedented Storm of December 15–16, 2021 — Updated Jan 27 —." National Oceanic and Atmospheric Administration. https://www.weather.gov/mpx/HistoricStormDecember2021.

———. n.d. "What Is the Polar Vortex?" National Oceanic and Atmospheric Administration. https://www.weather.gov/safety/cold-polar-vortex.

Osaka, Shannon. 2025. "There's a Reason Electricity Prices Have Been Rising. And It's Not Data Centers." *Washington Post*, October 25. https://www.washingtonpost.com/climate-environment/2025/10/25/data-centers-electricity-prices-rise/.

Pasch, Richard J., Robbie Berg, David P. Roberts, and Philippe P. Papin. 2021. *National Hurricane Center*

Tropical Cyclone Report: Hurricane Laura. NHC AL132020. National Oceanic and Atmospheric Administration. https://www.nhc.noaa.gov/data/tcr/AL132020_Laura.pdf.

Petit, Frederic, Vanessa Vargas, James Kavicky, Michael Kintner-Meyer, and Joseph Eto. 2020. *Grid Modernization: Metrics Analysis (GMLC1.1) – Resilience: Reference Document Volume 3*. PNNL-28567. Pacific Northwest National Laboratory. https://gmlc.doe.gov/sites/default/files/2021-08/GMLC1.1_Vol3_Resilience.pdf.

Potts, Jerry, Helena R. Tiedmann, Keri K. Stephens, Kasey M. Faust, and Sergio Castellanos. 2024. "Enhancing Power System Resilience to Extreme Weather Events: A Qualitative Assessment of Winter Storm Uri." *International Journal of Disaster Risk Reduction* 103 (March): 104309. https://doi.org/10.1016/j.ijdrr.2024.104309.

Prein, Andreas F. 2023. "Thunderstorm Straight Line Winds Intensify with Climate Change." *Nature Climate Change* 13 (12): 1353–59. https://doi.org/10.1038/s41558-023-01852-9.

Priest, A. Alexander, and James R. Elliott. 2023. "The Multiplicity of Impact: How Social Marginalization Compounds Climate Disasters." *Environmental Sociology* 9 (3): 269–83. https://doi.org/10.1080/23251042.2023.2215592.

Read, Amy. 2025. "Repeated Disaster and the Economic Valuation of Place: Temporal Dynamics of Tornado Effects on Housing Prices in the United States, 1980–2010." *Population and Environment* 47 (3): 29. https://doi.org/10.1007/s11111-025-00502-w.

Reed, Kevin A., Michael F. Wehner, and Colin M. Zarzycki. 2022. "Attribution of 2020 Hurricane Season Extreme Rainfall to Human-Induced Climate Change." *Nature Communications* 13 (1): 1905. https://doi.org/10.1038/s41467-022-29379-1.

Rokstad, Aaron. 2025. "How Electric Companies Can Reduce Liability Risks from Climate Change." *Utility Dive*, June 24. https://www.utilitydive.com/news/electric-utilities-liability-risks-climate-change-rokstad/751341/.

Shearer, Eric J., Vesta Afzali Gorooh, Phu Nguyen, Kuo-Lin Hsu, and Soroosh Sorooshian. 2022. "Unveiling Four Decades of Intensifying Precipitation from Tropical Cyclones Using Satellite Measurements." *Scientific Reports* 12 (1): 13569. https://doi.org/10.1038/s41598-022-17640-y.

Sievers, Brittany. 2020. "Natural Disaster Recovery and Agriculture: How to Keep the Crops Covered." *Drake Journal of Agricultural Law* 24 (3): 511–29. https://aglawjournal.wp.drake.edu/wp-content/uploads/sites/66/2025/04/Sievers-Final-Macro.pdf.

Smith, Adam B. 2025. "U.S. Billion-Dollar Weather and Climate Disasters, 1980 – Present (NCEI Accession 0209268)." National Centers for Environmental Information, National Oceanic and Atmospheric Administration. https://doi.org/10.25921/STKW-7W73.

Smith, Genee S., E. Anjum, C. Francis, L. Deanes, and C. Acey. 2022. "Climate Change, Environmental Disasters, and Health Inequities: The Underlying Role of Structural Inequalities." *Current Environmental Health Reports* 9 (1): 80–89. https://doi.org/10.1007/s40572-022-00336-w.

Snyder, Rachel. 2024. "Texas Appeals Court Allows Some Lawsuits Against Power Companies Related to 2021 Winter Storm to Move Forward." *WFAA* (Dallas, TX), April 6. https://www.wfaa.com/article/news/local/texas-appeals-court-ruling-allows-some-2021-winter-storm-lawsuits-against-oncor-others-move-forward/287-7899fa78-d814-40ed-98f6-c92055153d95.

Sovacool, Benjamin K., Sanya Carley, and Lynne Kiesling. 2024. "Energy Justice Beyond the Wire: Exploring the Multidimensional Inequities of the Electrical Power Grid in the United States." *Energy Research & Social Science* 111 (May): 103474. https://doi.org/10.1016/j.erss.2024.103474.

Stough, Laura M., and Carol S. North. 2018. "The Association of Adverse Mental Health Effects with Repeated Exposure to Disasters." *Annals of Clinical Psychiatry* 30 (1): 17–24. https://doi.org/10.1177/104012371803000104.

Tippett, Michael K., Chiara Lepore, and Joel E. Cohen. 2016. "More Tornadoes in the Most Extreme U.S. Tornado Outbreaks." *Science* 354 (6318): 1419–23. https://doi.org/10.1126/science.aah7393.

Trapp, Robert J., Kimberly A. Hoogewind, and Sonia Lasher-Trapp. 2019. "Future Changes in Hail Occurrence in the United States Determined through Convection-Permitting Dynamical Downscaling." Journal of Climate. *Journal of Climate* 32 (17): 5493–509. https://doi.org/10.1175/JCLI-D-18-0740.1.

Troutman Pepper Locke. 2024. "Texas Supreme Court Issues Electric Opinion on PUC Orders During Winter Storm Uri." July 12. https://www.jdsupra.com/legalnews/texas-supreme-court-issues-electric-1886037/Irwin.

TX DHS (Texas Department of State Health Services). 2021. *February 2021 Winter Storm-Related Deaths – Texas*. https://www.dshs.texas.gov/sites/default/files/news/updates/SMOC_FebWinterStorm_MortalitySurvReport_12-30-21.pdf.

Uehling, John, and Carl J. Schreck III. 2024. "Observed Changes in Extreme Precipitation Associated with U.S. Tropical Cyclones." *Journal of Climate* 37 (14): 3661–74. https://doi.org/10.1175/JCLI-D-23-0327.1.

van Oldenborgh, Geert Jan, Karin van der Wiel, Antonia Sebastian, Roop Singh, Julie Arrighi, Friederike Otto, Karsten Haustein, Sihan Li, Gabriel Vecchi, and Heidi Cullen. 2017. "Attribution of Extreme Rainfall from Hurricane Harvey, August 2017." *Environmental Research Letters* 12 (12): 124009. https://doi.org/10.1088/1748-9326/aa9ef2.

Vecchi, Gabriel A., Christopher Landsea, Wei Zhang, Gabriele Villarini, and Thomas Knutson. 2021. "Changes in Atlantic Major Hurricane Frequency Since the Late-19th Century." *Nature Communications* 12 (1): 4054. https://doi.org/10.1038/s41467-021-24268-5.*WeatherNation*. 2020. "Iowa Power Outages May Last A Week After Derecho." August 13. https://www.weathernationtv.com/news/iowa-power-outages-may-last-a-week-after-derecho.

Webb, Romany M., Michael Panfil, and Sarah Ladin. 2020. *Climate Risk in the Electricity Sector: Legal Obligations to Advance Climate Resilience Planning by Electric Utilities*. Sabin Center for Climate Change Law. https://scholarship.law.columbia.edu/sabin_climate_change/44.

Wolfe, Elizabeth, Rob Shackelford, and Joe Sutton. 2023. "Nearly 1 Million Power Outages Reported in Cross-Country Winter Storms, with More Snow, Icing and Blizzard Conditions Ahead." *CNN*, February 24. https://www.cnn.com/2023/02/23/weather/winter-storm-us-thursday.

Young, Rachel, and Solomon Hsiang. 2024. "Mortality Caused by Tropical Cyclones in the United States." *Nature* 635 (8037): 121–28. https://doi.org/10.1038/s41586-024-07945-5.

The Union of Concerned Scientists puts rigorous, independent science into action, developing solutions and advocating for a healthy, safe, and just future.

https://doi.org/10.47923/2026.16071