From "Animal Crackers" to Winter Storm Uri

By Julie A. Cohn

Reflecting on Blackouts in the United States

Hey, that's-a good all right. The storm put the lights out, now nobody can see whatta we do. That's-a fine eh?
—Chico Marx, Animal Crackers, 1930

It was seconds and minutes [from possible failure] given the amount of generation that was coming off the system.
—Bill Magness, former president, Electric Reliability Council of Texas, 18 February 2021

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FOR THE PAST CENTURY, AMERICANS HAVE EXPERIENCED blackouts both accidental and intentional in many settings, under many circumstances, and for many reasons. Blackouts happen in real time, and we interpret their significance through imaginary as well as documentary depictions. In a 1930s Marx Brothers movie, for example, comical art thieves get to work when a storm causes the lights to go out, and the laughs follow (Figure 1). In the sharpest of contrasts, efforts to prevent a cascading power failure in February 2021 left millions of Texans without electricity for days, with widespread coverage in the news.

Blackouts can be traced to the start of indoor lighting and, more significantly, to the electrification of homes and buildings. Causes range from animal sabotage to equipment failure to weather events to operator intent. The scale, scope, and duration of blackouts follow the growth of interconnected systems. Elsewhere in this special issue, the engineering experts explore girding against power failures in the future. In the following historical excursion into the history of blackouts in the United States, we may find insights to frame our next technical steps.

Introduction

This narrative begins with a fictional blackout used as a comedy device, reflecting the casual response to power outages in the early 20th century. The sharply contrasting experience of a widespread controlled outage during Winter Storm Uri in 2021 follows. The article then traces the changing nature of blackouts over nearly 150 years and the reasons customers experienced outages so differently at different moments. The section "Conclusion: The Takeaway" offers some reflections on how fully electrification wraps around contemporary life and what this implies for future blackout experiences on the customer side of the meter.

So, let us settle in and start with a movie.

The Quotidian Blackout of *Animal Crackers*

How does one pull a heist in the middle of a house party? This is a quandary during the film *Animal Crackers*. In this 1930 Marx Brothers comedy, an aristocrat, Mrs. Rittenhouse (Margaret Dumont), has invited numerous friends to her mansion to meet the returning African adventurer, Captain Spalding (Groucho Marx), and to view her newly purchased painting, "After the Hunt," by "renowned" fictional artist Beaugard. Rival hostess Mrs. Whitely and her daughter contrive to embarrass Mrs. Rittenhouse by replacing the famed painting with the daughter's amateur copy, and they employ their former butler to do the deed. Meanwhile, Mrs. Rittenhouse's daughter, Arabella, and her beau, aspiring artist John Parker, also plot to replace the painting but with a close copy created by Parker. Their hope is that the quality of his work will sufficiently impress a visiting art impresario to guarantee Parker a source of income, thus making it possible for the young lovers to marry. They enlist two "decorated" guests, imposters played by Zeppo and Harpo Marx, to pull off the switch. With guests gathering constantly in the room containing the Beaugard, the thefts seem impossible… but power outages help.

For Zeppo and Harpo, alone with the painting, a convenient thunderstorm arrives and causes a blackout. Mrs. Rittenhouse and Captain Spalding come into the dark room, and Mrs. Rittenhouse complains, with only mild distress, "The storm has put the lights out and you can't see your hand before your face." They exit just before the lights come back on, and we then see Zeppo and Harpo rolling up the original painting and closing the curtains over the fake. Not long thereafter, we learn that the butler has also completed his switch. When the painting is unveiled to the guests, the impresario announces it is a "rank imitation." The guests are aghast. Captain Spalding takes over, stating, "Leave it to me, I'll shed some light on the subject," when, of course, the

figure 1. The Strand Theater advertisement for the American comedy film *Animal Crackers*, 1930. (Source: Paramount Pictures, Wikimedia Commons.)

thunder revives, lightning strikes, and all is dark again. The guests murmur, but there are no exclamations of fear or anxiety. When the lights come on this second time, the painting is gone, and the frame is empty. The remainder of the movie involves chase scenes, handoffs of canvasses, slapstick, and so forth. Ultimately, Harpo produces all three canvasses from his enormous coat pockets, and all is resolved.

In 1930, filmmakers found a blackout during a thunderstorm to be sufficiently commonplace that it could be used as a plausible plot device in a comedy movie. In addition, the film's dialogue employs numerous puns and references to the lack of lights, again underscoring that a sudden loss of electricity was not grounds for panic. In other films of the decade, blackouts offered opportunities for linesmen to perform acts of heroism, for murderous events to unfold, for theft and sabotage, and for romance to blossom.

As the historian of electrification David Nye explains in his 2010 book, *When the Lights Went Out*, the concept of a blackout has evolved over time, from a normal consequence of relatively young, mostly distributed, electrical systems to an anomalous event occurring on reliable, essential, and highly integrated grids. During the decades leading up to World War II, Americans enjoyed the numerous amenities afforded by access to electric power, especially brighter interior lighting, devices to facilitate both domestic and industrial work, and a wide variety of entertainment and transportation not previously available. However, most retained familiarity with life in an unelectrified world. Much like Mrs. Rittenhouse and her guests, Americans experienced blackouts as a familiar nuisance.

Over the course of the nine decades after 1930, the nature of power outages and their effects on Americans changed. Consider what happened when the lights went out for Texans in February 2021. Life came to a standstill for many across the state. News outlets used words like "paralysis," "disruption," "crisis," "failure," "deadly, "catastrophic," and "disaster" to describe the unfolding situation, hardly terms that evoke an everyday event. Indeed, the power outages of Winter Storm Uri were unique in multiple ways.

Winter Storm Uri, 14–19 February 2021

After several days of decreasing temperatures, capacity warnings, and rising demand, the system operators in the control room of the Electric Reliability Council of Texas (ERCOT) faced a worrying mismatch between generation and load on the Texas Interconnected System. Demand reached a new winter peak of 69,222 MW while available generating capacity fell away. At 1:23 A.M. on 15 February 2021, as frequency hovered just above 59.9 Hz, ERCOT issued the first of several load-shed orders. Over the next 32 min, frequency rose briefly, then fell precipitously to 59.302 Hz, spending four full minutes below 59.4 Hz before rising again. Frequency below 59.4 Hz for nine minutes or more is the threshold for the automatic tripping-off of generators on the ERCOT system. By 1:55 A.M., ERCOT had ordered the shedding of a total 8,500 MW of load and another 2,000 MW five minutes later. Figure 2 illustrates the unfolding crisis. This event marked the start of several cold and dark days for Texas power customers.

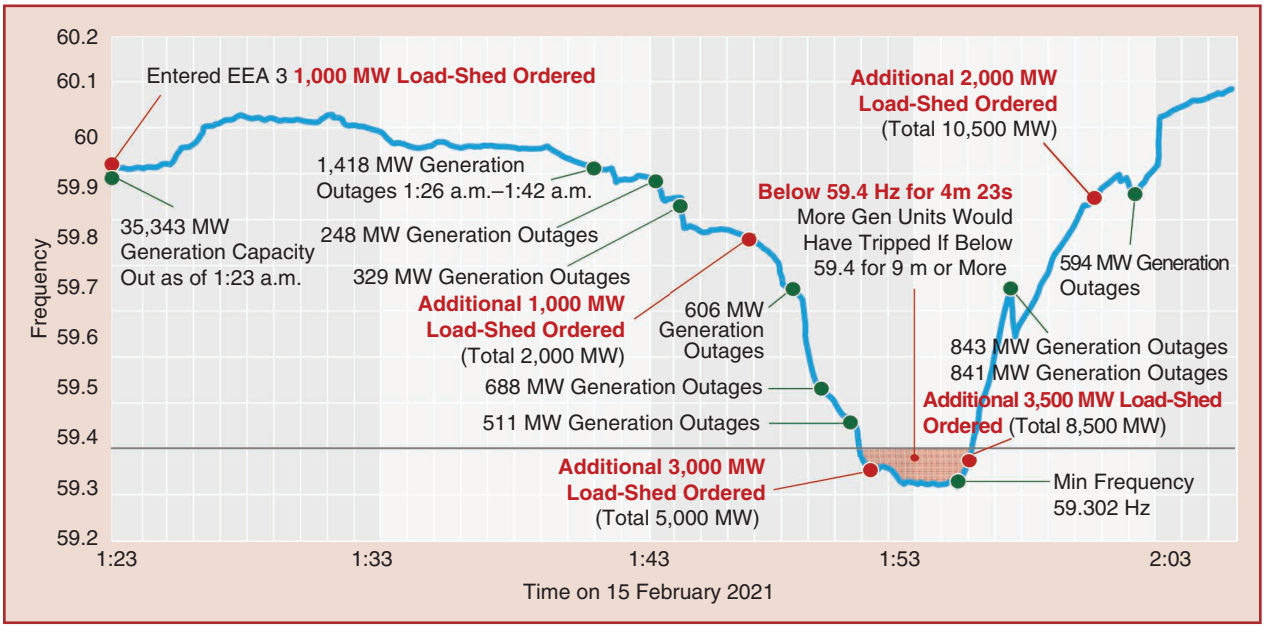

figure 2. The unfolding crisis of the February 2021 extreme cold weather event. At 1:23 a.m. on 15 February 2021, ERCOT issued an Energy Emergency Alert 3 (EEA 3) indicating that rotating outages were in progress. (Source: ERCOT, 2021, https://www.ercot.com/files/docs/2021/03/03/Texas_Legislature_Hearings_2-25-2021.pdf.)

A few proximate causes of the power outages during Winter Storm Uri were

1) extremely cold temperatures across a broad area for longer than in recorded history
2) loss of every type of generation due to freeze-offs or lack of fuel
3) lack of natural gas to fuel power plants due to freeze-offs or lack of electricity
4) exceptionally high demand for power (because it was so cold).

As a result, ERCOT called for curtailments to avoid a collapse of the grid.

A longer view of electrification in Texas suggests to this author that regulatory approaches, leadership shortcomings, and failure of imagination contributed to the power outages of February 2021. The state's energy-only competitive wholesale power market offers handsome rewards to those who invest in extras, such as winterization. Generators look to summer as the season to recoup those investments, when extreme heat leads to peak demand. With a general public focus on global warming and severe cold weather occurring only occasionally in Texas, it seemed possible that high winter demand would seldom arise. Over the past decade, few generators have winterized their facilities. Similarly, the intrastate natural gas industry had little regulatory requirement or incentive to prepare infrastructure for extreme cold. Further, the Public Utility Commission of Texas regulates the power industry within the state, while the Texas Railroad Commission (which has nothing to do with trains) regulates the gas industry.

Prior to 2021, there was no statutory requirement for coordination among these entities and their intertwined energy systems. Finally, one could argue that in its preparations for the cold season, ERCOT planners failed to incorporate experiences of the worst winter storm in recent history (in 2011) when estimating just how cold February might be and how hard the cold might hit the state's grid.

Following the winter storm, agencies at every level of government, researchers across the academic spectrum, and experts within the power industry examined the power outages, offered granular explanations of each moment in the event timeline, and proposed solutions from the technical to the regulatory. The Texas legislature passed new laws that addressed some of the proximate and longer-term causes of the outages. Lawsuits grind their way through the courts. Texans, along with others across the country, are left wondering when to expect the next blackout.

Major U.S. Blackouts

The Texas 2021 blackout lasted four days, affected 4.8 million power customers and 14 million water users, caused 246 or more deaths, and disrupted transportation, industrial activity, businesses, and personal lives across the state. However, this was not the most widespread U.S. blackout, nor the longest lasting, nor the most dangerous. Major power failures, though infrequent, have disrupted American lives for decades. The 1965 Northeast Blackout, on 9 November of that year, marked the first widespread, long-lasting, cascading power failure on the continent. Thirty million customers lacked power for up to 13 hours in eight states and the province of Ontario. Since then, hurricanes, winter storms, cascading failures, and controlled outages have periodically created havoc for millions of people across large regions.

What qualifies as a large-scale power outage in the United States? For some, blackouts refer to disruptions of electricity that affect more than one customer and last more than 5 min. The Department of Energy lists nine criteria for filing a disturbance report, including the loss of 300 MW for 15 min or more and emergency load shedding of 100 MW or more. Wikipedia, however, lists any unplanned outage that affects at least 1,000 people, lasts at least one hour, and causes at least 1,000,000 person-hours of disruption. In other words, a major blackout event or power outage may vary somewhat in the eyes of the beholder.

Focusing on the number of customers affected by a power outage, with 1,000,000 as the criterion, there have been more than 40 widespread outages since 1965. Table 1 offers a list,

table 1. The 12 largest North American power outages since 1965.

Location/Type	Year	Date	Number of Customers Affected
Northeast/cascading	2003	14 August	50,000,000
Northeast/cascading	1965	9 November	30,000,000
Pennsylvania/New Jersey/Maryland/cascading	1967	5 June	13,000,000
New York State/cascading	1977	13 July	9,000,000
Northeast/Hurricane Sandy	2012	29 October	8,200,000
Noncoastal West/cascading	1996	10 August	7,500,000
Southeast/Hurricane Isaias	2020	3 August	6,400,000
Northeast and Quebec/solar flare/cascading	1989	13 March	5,800,000
California/cascading	1982	22 December	5,000,000
East Coast/Hurricane Irene	2011	27 August	5,000,000
Southwest–California, New Mexico/cascading	2011	8 September	5,000,000
Texas and nearby states/controlled	2021	15 February	4,800,000

Sources: https://www.energy.gov/; DOE, 2003; Hines et al.; https://www.wikipedia.org/.

As geographer Veronica Jacome describes in forthcoming publications, utilities focused on reliability as a marketing tool to add and retain loyal customers.

probably disputable, of the 12 largest outages since 1965, eight considered cascading failures, three resulting from widespread hurricane damage, and one, in Texas, considered a controlled outage. This relatively small number of massive blackouts belies the customer experience of powerlessness. Reportable disturbances on the U.S. bulk power supply, not all of which are noticed by power users, occurred an average of 232 times per year over the past decade, which is four or five times per week.

Blackouts Across Three Centuries

Anxieties around the failure of artificial lighting, even before the advent of electrification, date back to the 19th century. As historian Peter Baldwin explains in his 2004 essay, "In the Heart of Darkness: Blackouts and the Social Geography of Lighting in the Gaslight Era," affluent observers worried that the loss of gas lighting would set off lower-class rampages. He documents gas system blackouts in 1848, 1868, 1871, 1872, and 1873, variously resulting from worker strikes, fires, and explosions. In the latter cases, serious loss of life and property ensued. In all cases, however, despite warnings of crime and mayhem on newly darkened urban streets, the blackouts caused inconvenience rather than disaster for those traversing the city.

In the earliest days of electrification, likewise, customers took power failures in stride. Generators were unreliable, squirrels chewed through power lines, bulbs burnt out, individuals sabotaged systems, lightning strikes brought down power plants, and the newfangled technologies were marvels rather than necessities. The precept that successful electrical systems should promise reliability emerged slowly at the turn of the last century. Indeed, according to David Nye, it was not until the 1940s that the notion of a blackout as a failure of the power system took hold.

Nye helps us parse what, exactly, the term "blackout" means, and it has changed over time. Through the 1910s and 1920s, the term referred to dimming of the lights in theaters. During the 1930s it appeared in medical literature. In the years immediately preceding and during World War II, Europeans and Americans practiced intentional blackouts, hoping to disguise their cities from nighttime air raids. Governments called for news blackouts, that is, embargo or censorship of certain stories, during the war. Nye identifies the first use of "blackout" as a reference to an accidental power failure in 1947.

For Nye, the evolution of the term aligns with the evolution of the industry. Power companies focused increasingly on reliability only after the early 1900s. At the same time, as systems expanded and the number of interconnections increased, the potential for a widespread outage increased. In addition, customers integrated electricity into more and more functions every day and thus grew more vulnerable to the challenges of a world without electricity.

The notion of electrification shifted from a luxury to a necessity in the early 20th century. Articles in the trade journal *Electrical World* reveal that in the early 1900s, power system experts strove to make electricity more commonly available by improving operating efficiency and lowering costs. At the same time, particular uses of electricity, for example, in the manufacture of textiles, required stable and continuous delivery of current. Engineers, operators, manufacturers, and academics responded to customers' demands for reliable electricity with innovations in operating practice; technologies for data collection, measurement, and calculation; and modeling devices. From analog to digital apparatus, from manual to automatic control, and from in-house practice to multicompany voluntary standards, system operations became increasingly sophisticated. Outages continued, but by the mid-20th century, system operators were highly sensitive to the dismay they caused. As geographer Veronica Jacome describes in forthcoming publications, utilities focused on reliability as a marketing tool to add and retain loyal customers. Nye notes that over time, North America's power grids were reputed to be the most reliable in the world. Because electricity service became more dependable, the loss of power became more problematic.

As Americans found an increasing variety of uses for electricity, power networks expanded dramatically. While the earliest interconnections date to the 1890s, power pools reached across distinct regions by the 1920s, covered multistate areas shortly thereafter, and stretched across half the continent in the early 1960s. For example, the interconnection that formed the kernel of today's Eastern Interconnection served customers only in portions of western Pennsylvania and eastern Ohio in the mid-1910s; included parts of Indiana and Illinois by 1930; stretched from Florida to the southern edge of New York State on the east side and from Mississippi through Illinois on the west side by 1938; reached all the way to Kansas, Oklahoma, and parts of East Texas during World War II; and covered most of the eastern United States and parts of Canada in 1964 as shown in Figure 3. By this date, most power systems in the United States and eastern Canada operated within five major interconnected networks and three smaller ones. While not all links within each network were electrically strong, the scale of

the interconnections indicated a high degree of dependency among participating utilities.

Rising power production accompanied system growth, as illustrated in Figure 4. By the early years of World War II, power generation had increased nearly 40-fold over 1902, and Americans relied on electricity for a broad range of activities, from domestic to commercial to industrial. Yet, as Nye notes, Americans tended to keep candles and matches nearby in readiness for the next power failure.

After the war, the use of power continued to increase in all sectors. In 2022, the latest year for which full data are available, we generated 711 times more electricity than in 1902, as shown in Figure 4. As interconnections grew across the century, and power production increased apace, power outages likewise disrupted larger and larger groups of people. Indeed, while the Marx Brothers' timely thunderstorm interrupted a single house party in 1930, a power failure in New York City affected more than 100,000 customers in 1936. Notably, in these years, power outages affected life most dramatically at night because that was the time of peak demand. In 1959, 500,000 customers lost electrical service during an outage in New York, and then, 30,000,000 were left in the dark in 1965. In the years following, with the advent of air conditioning, electric heating, and 24-h operations across many economic sectors, daytime blackouts became more problematic.

Further, Americans grew increasingly dependent upon electricity for a wide range of activities unimaginable at the start of the industry. From home lighting, heating, and plug-in appliances before World War II to industrial manufacturing to computing centers to high-tech medical facilities, uses for electric power were on the rise. Consider just one example: changes in interpersonal communications. In the past, one might have penned a message on a piece of paper, sealed it in an envelope, placed it in a mailbox, and waited while a series of postal workers transported, sorted, and delivered the letter to the recipient. Today, we rely on electrified desktop devices and battery-charged handheld devices to accomplish the same thing. In the past 10 years, physical mail volume in the United States dropped 20%, and first-class mail, which reached a high of 103,656 million pieces in 2001, fell to half as many in 2021. Meanwhile, e-mailers send and receive hundreds of billions of messages daily. From universities to military installations, from factories to

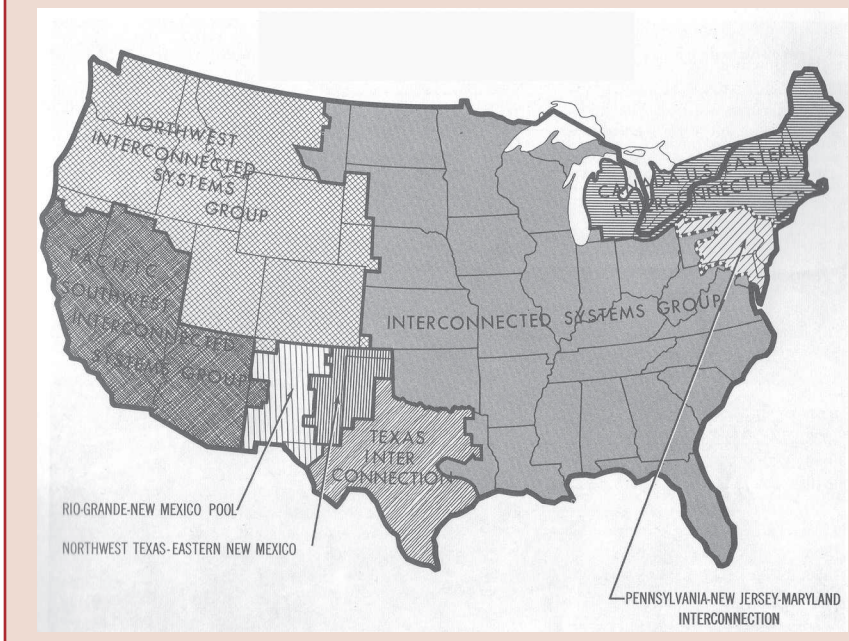

figure 3. The major areas served by interconnected systems. (Source: Federal Power Commission, 1964.)

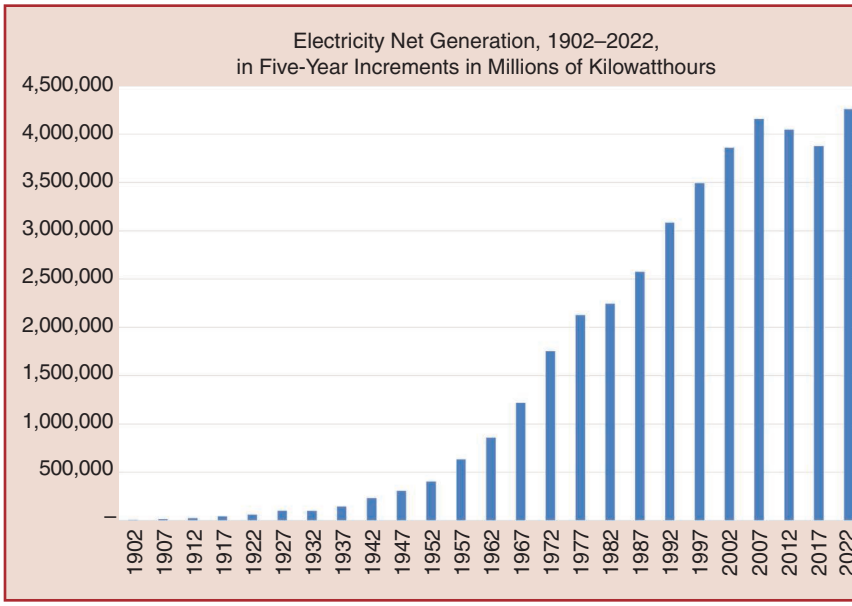

figure 4. Electricity net generation, 1902–2022 (in five-year increments through 2022). (Source: https://www.eia.gov/.)

kitchens, and from farms to offices, we live in a wraparound electrical world. Loss of power means loss of our ability to work, play, and thrive.

The nation's first major cascading power failure in 1965 resulted in enormous inconvenience, some degree of fear, and expensive repairs, but it was not marked by great loss of life. In fact, the public has a fond recollection of the event that is almost mythic. It occurred on an autumn evening, without rain or cold weather. Many who lived through that blackout will happily share their tales of sitting in darkened public buildings, helping direct traffic with flashlights, climbing out of stopped elevators, and sharing meals at candlelit restaurants. Others will repeat the story of a baby boom nine months later, although demographers and public health researchers thoroughly debunked this myth. A Doris Day film, *Where Were You When the Lights Went Out*, memorialized the blackout with comedy.

At the same time, the event raised consternation across multiple sectors about the efficacy of interconnections. Before the blackout, many thought that this type of blackout simply could not occur. Afterward, journalists, government officials, and utility executives pointed fingers in every possible direction. Congress considered, unsuccessfully, legislation to regulate the reliability of power systems. Individuals within the industry strove to organize an effective voluntary compliance organization, eventually establishing the National Electric Reliability Council (now the North American Electric Reliability Corporation) in 1968. Engineers continued work to strengthen the interconnected power systems and to prevent future massive power failures.

Similarly, widespread blackouts in the ensuing years resulted in handwringing, fraught finger-pointing, and eventually, in 2005, a formal federal role in grid reliability. Across three centuries, blackouts caused loss of light, loss of power, sometimes loss of mobility, and eventually, a crisis. As Nye illustrates, Americans have constructed a social understanding of what each blackout means, from the lighthearted acceptance of disruption in the early to middle 20th century to the deep anxieties and loss of property and life of the later 20th and early 21st centuries.

Conclusion: The Takeaway

The movie *Animal Crackers* presented an unexpected blackout as mundane but opportunistic. The filmmakers reflected a longer history of blackouts dating back to the gas light era. By the advent of World War II, nearly all urban and suburban Americans used electricity, but familiarity with a nonelectric world lingered. Power companies interconnected into larger and larger networks, and experts tackled the challenges of stability and reliability, yet continuous synchronous operation was still relatively new. The expansion of interconnected systems accelerated during and after the war, and while operators adopted standards to strengthen the grid, the networks in some ways became more fragile. The 1965 Northeast Blackout firmly exposed this inherent tension in our power grids.

Technical innovation, system operation, and infrastructure maintenance all contribute to stable, reliable, and resilient power systems. Economic, political, and organizational factors frame the size, shape, and nature of these systems. External, and sometimes unforeseen, events, from squirrels gnawing cables to storms and from human error to sabotage, can precipitate system failures. Grid managers occasionally produce power outages to prevent failures. These are the fora in which investigations into blackout prevention take place. However, on the other side of the meter reside the customers, who experience blackouts in particular ways. In the 21st century, the electrical world seems "natural," and many consider access to electricity a human right. A nonelectrical world seems, paradoxically, unnatural. Addressing blackouts going forward, from prevention to recovery, calls for achieving resilience on both sides of the meter.

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Biography

Julie A. Cohn is with Rice University, Houston, TX 77005 USA and the University of Houston, Houston, TX 77004 USA.