TOP 7 REASONS WHY THE **GRID WILL FAIL**

VARIETY OF EVENTS COULD PLUNGE US INTO DARKNESS

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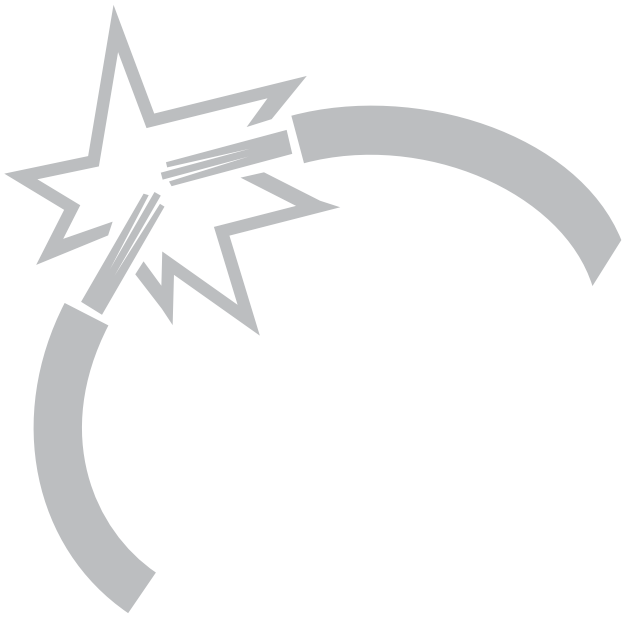


INTRODUCTION

Back in the days when bad weather was seemingly the only thing that knocked out power to our homes in the United States, nobody was overly worried. We figured it was inevitable that it would happen once in a while, and as long as power was restored within a few hours, nobody would suffer too much.

But some not-so-funny things have been happening in recent years. Violent weather has become more frequent and more intense, including rainstorms and snowstorms, tornados and hurricanes. Not to mention droughts and flooding, and deep freezes and wildfires. These events have exposed the vulnerability of our deteriorating electrical infrastructure, but they are hardly alone anymore when it comes to threats to the grid.

Weather events are now accompanied by other threats, including physical attacks carried out by terrorists with guns and other weapons, cyber attacks conducted by hackers, massive solar flares, intentional electromagnetic pulse attacks, and a variety of accidental disruptions. All of these events can disable a weak electrical grid, not just for hours or even days, but perhaps for weeks, months and even years, depending on their severity.

Our society has become completely dependent upon electricity for its daily existence. We require it for our jobs, our economy, our healthcare and even our leisure activities. When the power goes out for even a short period of time, we're thrown into chaos and the result is the loss of income, flooded basements and sometimes even deaths in extreme weather.

But a long-term collapse of the grid would do far more damage than plunging Americans

into the dark. If the grid were to go down for any length of time, transportation systems would grind to a halt and essential deliveries would be left unmade as the supply chain for everyday necessities is severely disrupted. This means that everything we count on being available at the stores we go to – from food and medicine to tools and hygiene products – might not be there when we need them.

The experts are telling us that it's not a matter of "if" the electrical grid goes down for a lengthy period of time, but "when." They're calling the U.S. power grid the country's "glass jaw."

More than 200,000 miles of high-voltage transmission lines crossing North America supply 1,800 utilities responsible for running approximately 5,800 power plants with the power that homeowners and businesses use for lighting, refrigerators, air conditioners, heating, televisions and stereos.

Even the military gets 99 percent of its power the same way everyday citizens get it – from commercially run companies. Those lines are all at risk, including the ones serving the hospitals we depend on to care for us and the police stations we depend on to protect us.

In a recent article, the *New York Times* reported: "If an adversary lands a knockout blow... it could black out vast areas of the continent for weeks; interrupt supplies of water, gasoline, diesel fuel and fresh food; shut down communications; and create disruptions of a scale that was only hinted at by Hurricane Sandy and the attacks of September 11."

When the power grid fails and does not come back online in a timely fashion, civil unrest is certain to break out. The lack of heating and cooling – depending on the season – could easily result in a significant number of deaths, as shelters would have no more power than homes and businesses.

"The power grid, built over many decades in a benign environment, now faces a range of threats it was never designed to survive," said Paul Stockton, a former assistant secretary of defense and president of risk-assessment firm Cloud Peak Analytics, in a *Wall Street Journal* article. "That's got to be the focus going forward."

In this report, we'll look at the seven most likely scenarios that will cause an electrical grid failure the likes of which we've never seen before.

EXTREME WEATHER

According to the Edison Electric Institute, 70 percent of power outages in the U.S. are caused by the weather. Rainstorms, snowstorms and ice storms, usually accompanied by high winds, are the most frequent abusers of the electrical grid, but weather events that inflict the most long-term damage include hurricanes and tornadoes. Of course, earthquakes can also cause long-term outages.

As we saw with Hurricanes Katrina and Sandy, violent weather events can leave

large geographic regions without power for extended periods of time. More recently, the historic storm named “Nemo” that struck the Northeast U.S. and Canada in early 2013 resulted in record snow amounts (including 40 inches in Hamden, Connecticut), hurricane-force wind gusts, approximately 700,000 homes and businesses losing power, and 18 deaths.

It’s not only violent storms that wreak havoc on an aging electrical grid. Intense heat in the South, Southwest and West has also been responsible for power outages, as has the extreme cold in the North and Northeast.

In fact, it was extreme heat that caused high-voltage lines to stretch and sag onto overgrown tree branches in northern Ohio in 2003, resulting in the worst blackout in North American history. Approximately 50 million people were plunged into darkness for two days in states from Ohio to Michigan to Massachusetts and even southeastern Canada as one electronic failure led to another in a cascade of collapse. Eleven deaths and $6 billion in damages were blamed on the accident that shut down 100 power plants.

PHYSICAL SABOTAGE

In April 2013 near San Jose, California, there was an attack on a power transmission substation. Shortly after telephone cables were cut, multiple snipers fired shots on the Pacific Gas & Electric Corporation’s Metcalf substation. It took nearly a month for workers to make the repairs and bring the substation back to life. To this day, no one has been arrested in connection with the sabotage. Was this an isolated incident conducted

Back in 1977, a lightning-sparked outage left 9 million New Yorkers without power. Notable weather-related blackouts in the U.S. since the turn of the century have included:

- North Carolina and Virginia in 2003, when power to more than 2.2 million customers was interrupted by Hurricane Isabel.
- Florida and Alabama in 2004, when power to 5 million homes and businesses was disrupted by various hurricanes.
- Alabama, Florida, Louisiana and Mississippi in 2005, when power to 2.2 million customers was interrupted by Hurricane Katrina.
- Oklahoma, Kansas and Nebraska in 2007, when a series of ice storms cut power to more than 1 million homes and businesses.
- Texas in 2008, when Hurricane Ike left more than 2 million customers without power, including some whose power was not restored for 16 days.
- Connecticut and Massachusetts in 2011, when a snowstorm caused more than 2 million outages, including some that lasted over a week.
- Twenty-four different states in 2012, when Hurricane Sandy left more than 10 million people without power, some for weeks.
- Florida, Georgia and other states, when Category 5 Hurricane Michael killed 59 people in the U.S., caused $25.1 billion in damages and disrupted power for more than 1 million people.
- Florida, the Carolinas and Virginia in 2019, when Hurricane Dorian caused numerous deaths and $1.2 billion in U.S. damages, and knocked out power for hundreds of thousands.

by vandals, or was it a dress rehearsal by terrorists? What really matters is that the incident proved the grid is terrifyingly vulnerable to a terrorist attack. It showed that a coordinated attack on substations in major cities across the country could plunge much of the country into the dark, possibly for an extended period of time. The fact is, other critical electrical grid sites remain just as unprotected as this one was.

Jon Wellinghoff, former chairman of the Federal Energy Regulatory Commission, said that the attack was "the most significant incident of domestic terrorism involving the grid that has ever occurred" in the U.S.

There are three large regional power grids in the United States (Eastern, Western and Texas). These independent grids have limited connections between them, thanks to technical obstacles, making it difficult for them to come to the assistance of each other in the case of an emergency.

There is much debate regarding how easy it would be to shut down all three electrical grids simultaneously, but experts agree that the U.S. could suffer a coast-to-coast blackout if terrorists disabled only NINE of the nation's 55,000 electric transmission substations on a hot summer day. A knockout punch of this magnitude could darken the country for weeks and possibly months!

"Destroy nine interconnection substations and a transformer manufacturer and the entire United States grid would be down for at least 18 months, probably longer," says a memo prepared for Wellinghoff.

Coordinated attacks in each of the three systems could cause the entire power network to collapse, according to the Federal Energy Regulatory Commission. Losing key substations would be devastating because they use large power transformers to boost the voltage of electricity so that it can move great distances before reducing the voltage to a usable level as that electricity gets closer to businesses and homes.

There are several reasons why this is a very scary situation. For one, there are no federal rules that require utilities to protect vital substations, except for those at nuclear power plants. Perhaps worse, transformers are very difficult to replace. Only a few factories in the U.S. build them, so we would be dependent on foreign help should this horrific scenario ever happen.

Another reason we should be worried is that the attack in California "demonstrates that it does not require sophistication to do significant damage to the U.S. grid," according to the memo, which also indicated that blackouts caused by this kind of significant damage could be very lengthy.

Ross Baldick, a professor of electrical engineering at the University of Texas at Austin, said, "This would be an event of unprecedented proportions."

If an attack like this were to occur during times of extreme weather, extended power outages could result in hundreds or even thousands of deaths due to heat stress or

extended exposure to extreme cold, according to a National Research Council report titled, "Terrorism and the Electric Power Delivery System."

Some large utilities are doing what they can to secure their facilities, but the costs can be astronomical. Officials at Dominion Resources, Inc., in Virginia said they planned to spend $300 to $500 million during a seven-year span to harden their facilities.

CYBER ATTACKS

"The electric grid's vulnerability to cyber... attacks is one of the single greatest threats to our national security," says Representative Ed Markey, a Massachusetts Democrat.

Physical attacks against the U.S. electrical grid may be more dramatic than cyber attacks, but cyber attacks are much more frequent. In fact, one power company reported that it receives approximately 10,000 attempted cyber attacks per month. Ten thousand per month! At one utility! Many other electrical utilities are reporting either daily or frequent cyber attacks, including probes on their networks that are searching for vulnerabilities.

According to the (Colorado Springs) *Gazette*, thousands of cyber attacks strike power grids in the U.S. every day. Former House Intelligence Committee Chairman Mike Rogers said at a recent Reuters summit on cyber terrorism that the only thing holding terrorists back from launching a massive cyber attack on U.S. infrastructure is that they don't have the ability. If a terrorist group finds out how to do it, Rogers said, "it's a game changer. My concern is it's just a matter of time."

A recent National Academy of Sciences report stated that, "If they could gain access, hackers could manipulate (control and data) systems to disrupt the flow of electricity... block the flow of vital information, or disable protective systems." The report added that a successful attack could "entail costs of hundreds of billions of dollars" and could render entire swaths of the country helpless to extreme weather.

A *Wall Street Journal* article that shook readers merely by its headline – "Hacking the Grid is Very Easy" – revealed that while the systems that are used to control industrial equipment, such as turbines and other power-generation gear, are supposed to be offline, they are actually often connected to the Internet and are therefore exposed to cyber attacks. These flaws in the security process are what make electric utilities vulnerable to cyber attacks.

The good news is that as our power generation systems become more complex, they become more reliable. But at the same time, they become more vulnerable because as the design becomes more complex, the interactions between the components start to dominate the overall design.

And because there are many potential interactions in systems with large numbers of components, it becomes virtually impossible to identify or test for every possible cause of

failure. As a result, unexpected failures can still cause catastrophic results.

Joel deJesus, an attorney at Schiff Hardin and a former official at the North American Electric Reliability Council, an industry group that focuses on regulatory policy, says, "The industry is doing all it can do, but cyber security issues are constantly evolving. There is no 100 percent guarantee that [power] assets will be fully protected."

Some of our utilities' vulnerabilities to cyber attacks are only discovered due to the diligence of private citizens. The *Los Angeles Times* reported that Adam Crain, owner of a small tech firm in Raleigh, North Carolina, along with a research partner, discovered that penetrating the transmission systems used by dozens of utilities was surprisingly simple.

When their findings were shared with utility security officials, the Homeland Security Department sent alerts to power grid operators, recommending that they upgrade their software. By continuing to find new security holes, Crain is keeping them busy. Thankfully, he's one of the good guys.

Demonstrating how serious the problem is, insurance giant Lloyds of London is turning down approximately 50 percent of the requests from power companies for protection against the risk of cyber attack because security is too weak.

"When Lloyds won't insure you, you know you've got a problem," said Patrick Miller, founder of the Energy Sector Security Consortium, a nonprofit firm based in Washington which pushes for tougher cyber security measures for the electricity industry.

A Congressional report noted that sophisticated cyber saboteurs may already be probing our vulnerability to a massive blackout, as evidenced by continual attempts to infect utilities' computer networks with malware and searches for security flaws. If these hackers succeed in penetrating utility companies' electronic defenses, they could potentially give instructions to key pieces of equipment that would cause them to fail.

Researchers at the Department of Energy's Idaho National Laboratory demonstrated that an attacker could instruct an electrical generator's turbine to spin wildly out of control until smoke began pouring out. In 2010, a piece of malware called Stuxnet destroyed as many as 1,000 centrifuges in an Iranian nuclear fuel-processing plant in an attack that some believe was launched by Israeli or U.S. agencies.

"We are woefully unprepared for any large-scale geographic outage that might take place over an extended period of time," explained Joel Gordes, research director for the U.S. Cyber Consequences Unit.

If critical equipment is damaged beyond repair, replacement units would have to be transported long distances, a task that would be made more daunting if communications systems were also seriously damaged by the attack.

EMP ATTACKS

On August 30, 1961, the Soviet Union announced that it would end a three-year moratorium on high-altitude nuclear testing. The U.S. response, carried out by the Atomic Energy Commission and the Defense Atomic Support Agency, was a well-documented series of five tests in 1962 called Operation Fishbowl. One of those tests, the Starfish Prime project, launched on July 9 and successfully detonated at an altitude of about 250 miles, producing a yield that was

Here's what some others have to say about a potential EMP attack:

- "The consequences would be catastrophic." – Joseph McClelland, director of the energy commission's Office of Electric Reliability.
- "It would bring down the whole grid and cost between $1 trillion and $2 trillion" to repair. – Representative Roscoe Bartlett, a Republican from Maryland. He added that full recovery could take up to 10 years.
- "EMP is one of the small number of threats that could hold at risk the continued existence of U.S. civil society." – Dr. Robert Hermann, commissioner of the U.S. Congress EMP Commission.
- "We talk a lot about a nuclear bomb in Manhattan and cyber security threat to the power grid in the Northeast, and all of these things would actually probably pale in comparison to the devastation that an EMP attack could perpetuate on Americans." – Representative Michael McCaul, a Republican from Texas.
- "In a matter of weeks or months at the most, a worst-case scenario could bring devastation beyond imagination." – Former Representative Trent Franks, a Republican from Arizona.
- "Natural EMP from a geomagnetic superstorm, like the 1859 Carrington Event or 1921 Railroad Storm, and nuclear EMP attack from terrorists or rogue states, as practiced by North Korea during the nuclear crisis of 2013, are both existential threats that could kill nine of 10 Americans through starvation, disease and societal collapse." – Dr. Michael J. Frankel, a former senior scientist at Pennsylvania State University.
- "It is an enormous catastrophic threat." – Newt Gingrich, politician, historian, author and political consultant.
- On the bright side, the Federal Energy Regulatory Commission has been pushing Congress for the authority to require power companies to take protective steps, including possibly building metal shields around sensitive computer equipment.

the equivalent of approximately 1.4 megatons of TNT.

The explosion resulted in an electromagnetic pulse (EMP) much larger than anticipated, illuminating a large area of the Pacific Ocean, causing electrical damage in Hawaii some 900 miles away from the detonation point, and trapping high-energy electrons to form radiation belts around the earth that disabled one-third of the satellites in low earth orbit and caused other satellites to fail over time.

EMPs are large outbursts of atmospheric electricity. They can be powered by nuclear blasts or geomagnetic storms, and the intense magnetic fields that result can induce ground currents powerful enough to burn out power lines and electrical equipment across wide areas.

One of the reasons the U.S. is concerned about the possibility of terrorists employing an EMP as a weapon against us is that such a bomb (or bombs) could be developed using inexpensive supplies and basic engineering knowledge. A low-level EMP could temporarily jam electronics systems, while more intense pulses could corrupt essential computer data. A very powerful burst could completely dismantle electronic equipment. It's actually possible to use such a weapon to render an

enemy's military almost useless while taking very few lives.

If an enemy were able to detonate a nuclear weapon high above the U.S., radiation would interact with the Earth's magnetic field and atmosphere, including the ionosphere, which is used for radio communications. The strong electrical current that would radiate down to the Earth would create additional currents that would course through manmade electrical circuits. Our electrical infrastructure and electronic devices would receive severe shocks, causing widespread damage and "unprecedented cascading failures," according to a congressional commission.

The damage would be catastrophic and life as we know it would be over, possibly for an extended period of time. Immediate failures would be evident everywhere, from essential infrastructure such as power, water and gas utilities; banking systems and ATMs; transportation of food, water and other goods; and emergency services. Military defenses would also be negatively affected. It would take years to repair the damage.

By its own admission, the Department of Homeland Security is not prepared to deal with such an attack. Even if the attack were more localized, the damage would be significant. An attack on the Washington, D.C.-Baltimore region, for example, could damage 10 percent of communications systems and the electrical grid, as well as 20 percent of electronic devices, according to a Congressional Research Service report. Recovery time would be one month and economic losses would be approximately $34 billion.

Is such an attack possible? Congresswoman Yvette Clarke, a Democrat from New York and a senior member of the House Homeland Security Committee, certainly thinks so. She says that the likelihood of a severe geomagnetic event capable of crippling our electric grid is 100 percent. And she's not alone in her assessment.

EMP FROM SOLAR FLARES

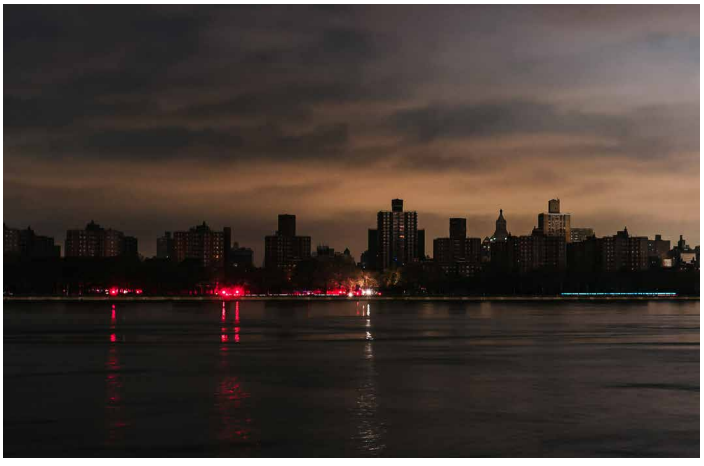
Are you familiar with the Carrington Event? It occurred more than 160 years ago and its effects were pretty minimal. But if anything like it happens again – and scientists are convinced it will – the effects could be devastating.

Named after Richard Carrington, a solar astronomer who witnessed the incident, the Carrington Event was a super solar flare that shot directly toward the Earth and manifested itself in a mammoth cloud of charged particles and detached magnetic loops that crashed into Earth's magnetic field the next day.

Causing the global bubble of magnetism that surrounds our planet to shake and quiver, and turning skies all over Earth red, green and purple, this solar storm produced a high intensity burst of electromagnetic energy (now known as an EMP) that disrupted communications, shocked technicians and set telegraph paper on fire when it shot through telegraph lines.

David Hathaway, solar physics team lead at NASA's Marshall Space Flight Center in Huntsville, Alabama, says that records indicate the Carrington Event was nearly twice as large as any other solar flare in at least the past 500 years. If anything even close to that event occurs in a modern society, hundreds of satellites in orbit will be at risk, not to mention power grids on Earth.

Fortunately, there wasn't a whole lot to disturb in 1859 in terms of electronics. Resting comfortably in their little house on the prairie, Ma and Pa Ingalls probably didn't even notice it. But if a powerful solar storm were to target Earth today, it could wreak havoc on our electrical grids that support communications, computers, electrical appliances and much more. The kind of super solar storm that lines up with an orientation perfectly opposite the Earth's own magnetic field might occur approximately every 100 years. If so, we're more than 60 years overdue.



We've definitely had some scares since the Carrington Event. In 1972, a huge solar flare knocked out long-distance telephone communication across Illinois. Seventeen years later, another flare from the sun disrupted electric power transmission from the Hydro Quebec generating station in Canada, blacking out most of the province and causing 6 million people to lose power for nine hours.

In 2006, a solar flare was so intense that it damaged the instrument taking a photo of it from a satellite more than 90 million miles away.

Today, X-ray telescopes in space and radio telescopes in space and on Earth can alert us that solar flares are on the way, but even that advance information probably won't help us avoid disastrous results to our communications systems if a flare similar to the one that struck in 1859 comes calling.

Bruce Tsuritani of NASA's Jet Propulsion Laboratory in Pasadena, California, and other solar physicists believe that another monster flare is inevitable in the next 10 to 100 years.

Yousef Butt, a scientist at Harvard University's Center for Astrophysics, stated in an article in the online journal *Space Review* that the likelihood of a devastating EMP from a solar storm is greater than that from an intentional EMP attack.

"Just one violent active region on the sun can cause continent-wide, perhaps even planetary-scale, impacts to our critical infrastructure," said John Kappenman, principal investigator for the U.S. Congress EMP Commission.

Captain Jim Terbush of NorthCom Science and Technology Directorate Innovations and Experimentation says that a solar storm or flare that destroys computer chips "could happen." He added, "That's not an unrealistic threat."

With the sun in an active state and with vehicles, cell phones, computers, traffic signals, airplanes, water systems and much more all running on computer chip technology, if they are cooked by a solar flare, it's a whole new ballgame.

AGING GRID

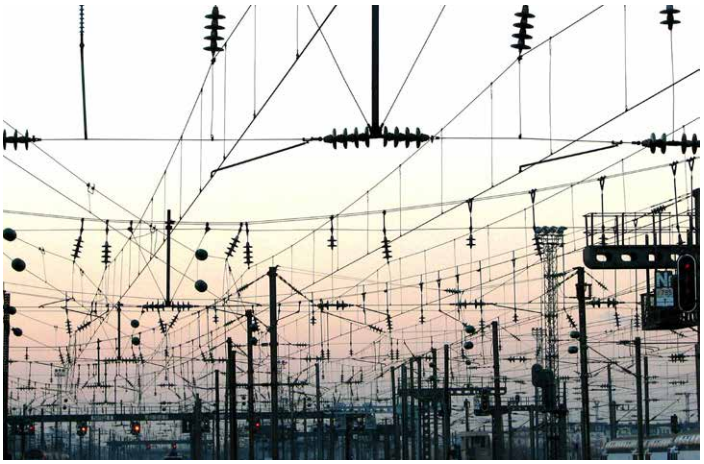
As we've discussed, there are a number of serious threats to the electrical grid in the U.S. But even if none of them were to occur – a highly unlikely scenario – there is still a good chance the grid would give out on its own before too long. It would be like someone dying of old age.

Even the U.S. government acknowledges that the grid is hurting. A recently declassified report revealed that due to old technology, lack of spare capacity and the inability to keep pace with the increasing power burden, the electrical grid is vulnerable. The system is simply antiquated and overtaxed. It still relies on 1960s and '70s technology to power a great majority of the country.

The electrical grid is made up of a patchwork of interconnected power generation plants, transmission facilities, distribution facilities and more than 200,000 miles of electric transmission lines, some of which actually date back to the 1880s.

According to an article in the *Washington Post*, U.S. electric customers are now paying 43 percent more to build and maintain local power grids than they did back in 2002. At the same time, the grid is also becoming less reliable, with blackouts now taking 20 percent longer to fix.

Jack Strauss, an economist at the University of Denver's Daniels College of Business, said, "The United States is poor in infrastructure replacement," while referencing an annual report by the American Society of Civil Engineers that gave the nation's infrastructure a grade of D+.



The truth is, the grid is already failing with regularity. From 1965 through 2009, there were 57 major grid failures in the United States and Canada, 41 of which were shared by the two countries, according to a study by the Institute of Electrical and Electronics Engineers. Each failure affected at least 30,000 people.

The Institute's report concluded that incidents of major power outages have been increasing everywhere, especially over the last 20 years.

In addition to its age, the electrical grid also has a design flaw – cascading failure, like a line of falling dominoes, can occur after one part of the grid breaks down. An article in *National Geographic*, Iowa State University engineering professor Ian Dobson explained that each failure weakens the entire system.

"On a bad day," he said, "something else happens. Usually it doesn't, but on that day, let's say it does. If it's a really bad day, then a third thing happens and the system becomes degraded. You're in a situation where it's more likely that the next failure is going to happen because the last failure already happened.

"That's the idea of cascading failure... Everything in the power system is protected so it doesn't fry when something goes wrong. Things can disconnect to protect the equipment, but if you disconnect enough things, you get a blackout."

In the classic example of a cascading failure, three sections of India's massive electrical grid collapsed in 2012, leaving 620 million people without power for several hours. It was the biggest blackout in recorded history.

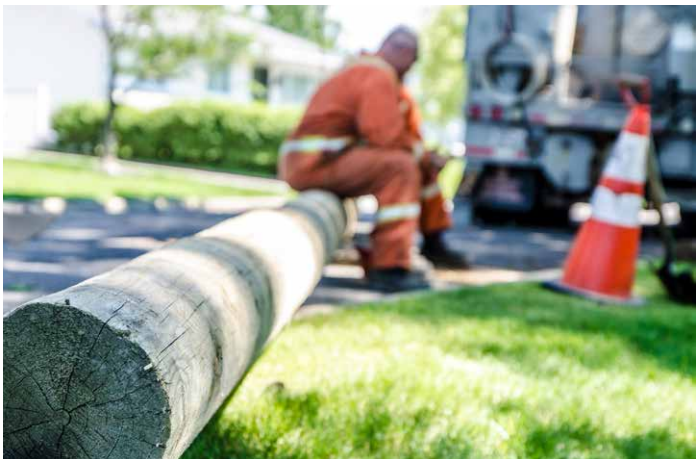
ACCIDENTAL CAUSES

As if extreme weather, manmade and solar electromagnetic pulses, and physical and cyber attacks were not enough to threaten the aging U.S. electrical grid, accidental causes are also responsible for causing power outages over vast regions. While it's true that many of these types of outages are repaired quickly, others have been known to last for days, weeks or even months.

While it's not surprising that weather causes a majority of power outages, many people are shocked to learn that an unusually high percentage of outages results from animals coming into contact with power lines, including large birds. Eleven percent of outages in the U.S. are attributed to this cause, according to the Edison Electric Institute. Of course, it's not only large animals that cause this damage. Even small animals can short-circuit the system by coming into contact with transformers, fuses and other electrical equipment.

Additional causes of accidental power failures include manmade outages in the form of vehicle and construction accidents involving power lines and poles. This can occur either above ground or underground. A common problem in this area is the accidental cutting of power lines. Also, trucks sometimes run into poles, breaking them and causing power lines to snap or come into contact with each other.

Human error, including mistakes by maintenance workers, is also a factor. Occasionally, equipment failures will occur that overtax the system until it shuts off automatically to protect other parts of the system.



Outages can even occur from a meteorite, such as the one that exploded over central Russia in 2013 and injured some 1,200 people, mostly from flying shards of glass after countless windows shattered. Unleashing a sonic boom, the explosion produced the power of a small atomic weapon and disrupted mobile phone networks.

CONCLUSION

When the government admits our electrical grid is decrepit, unreliable and likely to fail even without a major crisis, you know there's a big problem. The technology used to construct the grid is now old, there's very little in the way of spare capacity and the demand for electricity across the country continues to grow. All this is a recipe for disaster.

Meanwhile, the incidents of extreme weather continue to increase. In recent years, heat in the South, cold in the Plains and Midwest, and snowstorms in the Northeast have been relentless. Not to mention record-breaking numbers of hurricanes and tornados.

Add in the inevitable EMP that's right around the corner, the physical and cyber sabotage already occurring from our enemies that will only get worse, and construction accidents that occur on a regular basis... Well, you get the picture. Before too long, some Americans – maybe millions of Americans – will have to try to survive without an electrical grid for an extended period of time.

The alarms have been sounded, including by former Congressman Trent Franks of Arizona, a senior member of the House Armed Services Committee. Franks said, "We are only one act of madness away from a social cataclysm unlike anything our country has ever known."

It's only a matter of time before this country is thrown into darkness. The question that must be answered is, "Will you be prepared for it?"

I hope your answer is a resounding "yes."

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