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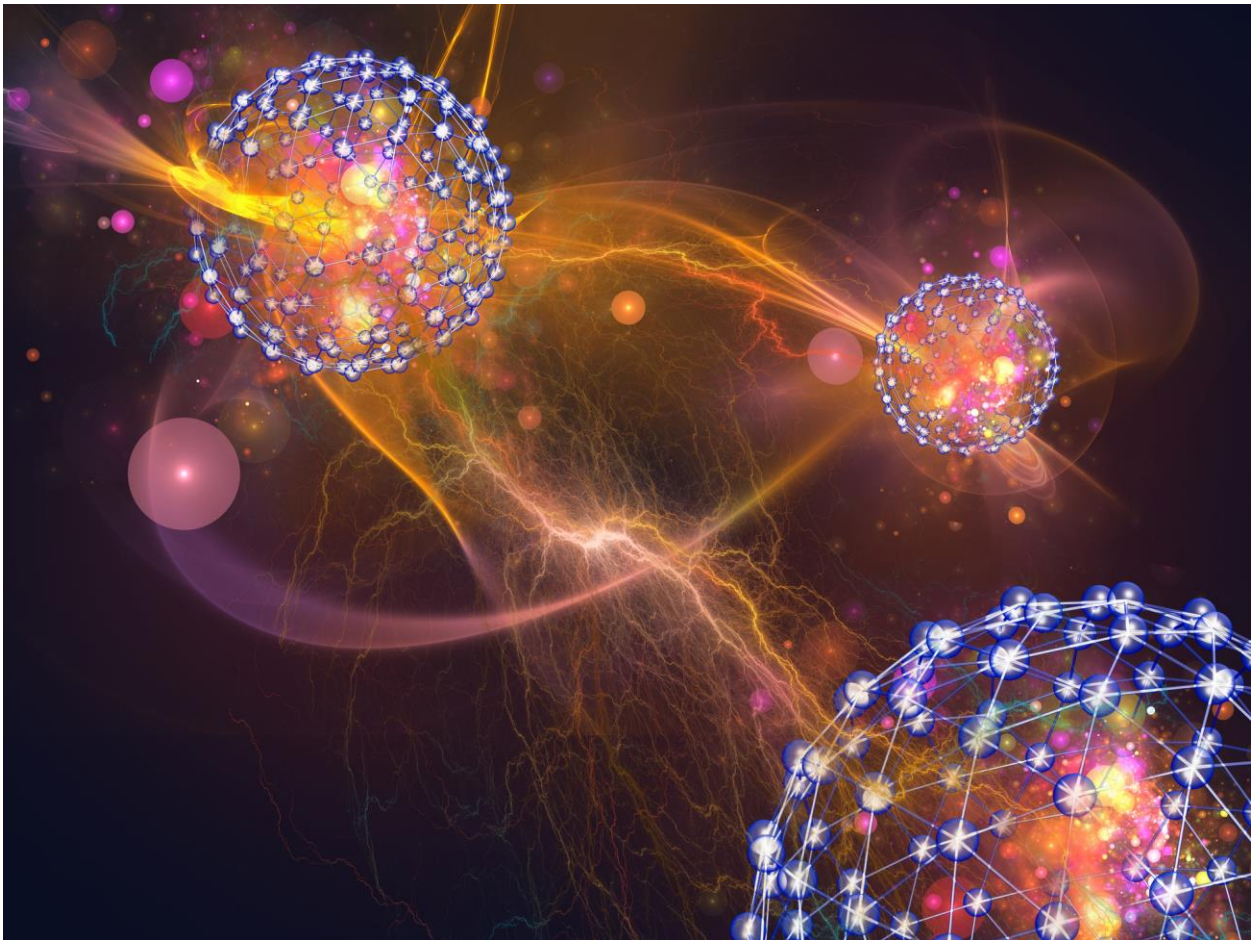
Reinventing Electrical Resiliency for the Biopharmaceutical Industry



Executive Summary

Crisis-proofing operations before the next event – whether it is a national health crisis or severe weather event – requires proactive business continuity planning and resilient mission critical support, including power systems.

The pharmaceutical industry is particularly vulnerable with often continuous and energy-intensive manufacturing processes, and even the smallest power interruption can halt production. Add an aging electric grid, and the situation becomes more precarious. For these reasons, microgrids are becoming a more popular solutions for manufacturing plants wanting to crisis-proof operations.

In this report, we discuss a variety of risks to electric infrastructure to demonstrate the impact on our current electric system. As the grid ages, human error and equipment failure are an increasing risk. The US grid is particularly susceptible to damage caused by natural disasters, such as floods, hurricanes, and wildfires. Trends predict these severe weather events to become more intense and more frequent, making them especially destructive to the power supply. We also discuss newer threats to the grid, such as cyberterrorism which have the capacity to shut down entire portions of the grid for extended periods of time.

The report then describes the ways in which commercial, industrial, and institutional organizations suffer because of power outages. The biopharmaceutical manufacturing industry is one of many that rely on consistent power, but undergo costly outages that negatively impact productivity, sales, and equipment.

Finally, we introduce solutions to electric resiliency through backup power. A plethora of different options are compared, ranging from traditional fuels to the newest technologies. The advantages and drawbacks of each option are discussed.

Introduction: Reliant on Power

Nearly every aspect of life in our modern society is fueled by electricity. From the moment we wake up and turn on the lights, our day is defined by access to continuous power.

Electricity keeps our homes comfortable and bright. It allows students to learn with the latest technologies in schools and universities. It keeps our food fresh in grocery stores and at home. It powers life-saving equipment in hospitals.

Continuous power is also a vital component for commercial and industrial business. More and more businesses are digitalized, and emerging opportunities often center around the latest technologies, such as artificial intelligence or robotics. Electricity keeps businesses in business.

In a cruel juxtaposition, just as society becomes more and more reliant on uninterrupted power, the grid becomes more and more vulnerable. The grid is aging and exposed, and threats to the electricity infrastructure are becoming more intense and more prevalent. Between human error, increasingly intense weather and skillful cyberattacks, the threat of power outage remains a costly issue.

The solution to this disparity between an unreliable supply and an unrelenting demand manifests as electric resiliency.

Grid Vulnerability

In a society dependent upon electricity, power failure is a major threat to business operations and human health. Unfortunately, the vulnerability of the grid suggests that power outages will be a long-term concern that is likely to worsen. For example, there were ten times as many reports of large scale power outages each year during the 2000s than in the 1980s and early 1990s.

Table 1 demonstrates the variety of threats, risks and hazards that can cause power system failures. While these events share the same consequence – power outage, they can differ in scale. This means some events affect more customers, damage more equipment or last longer, thus increasing their impact. In fact, grid vulnerability caused one of the largest power outages in United States history. Attributed to human error and equipment failure, the Northeastern Blackout of 2003 impacted around 50 million people across eight northeastern states and parts of southeastern Canada. The two-day blackout began when a high-voltage power line shut down after brushing against an overgrown tree in Ohio. This event should have been caught by an alarm, but it was missed. This simple mistake cost around $6 billion and resulted in over 90 new reliability standards.

Table 1 — Growing Risks to Electricity Infrastructure

Natural Hazards	Direct Physical Threats	Other Threats Hazards, and Vulnerability
Ice, snow and extreme cold weather	Physical attacks	Geomagnetic and electromagnetic pulses
Thunderstorms, tornados and hurricane-force winds	Cyber attacks	Aging infrastructure
Storm surge, flooding and increased precipitation		Capacity Constraints
Increasing temperature and extreme hot weather		Workforce turnover and loss of institutional knowledge
Earthquakes		Human Error
Wildfires		Dependencies and supply chain interruptions

Adapted from Argonne National Laboratory, 2016

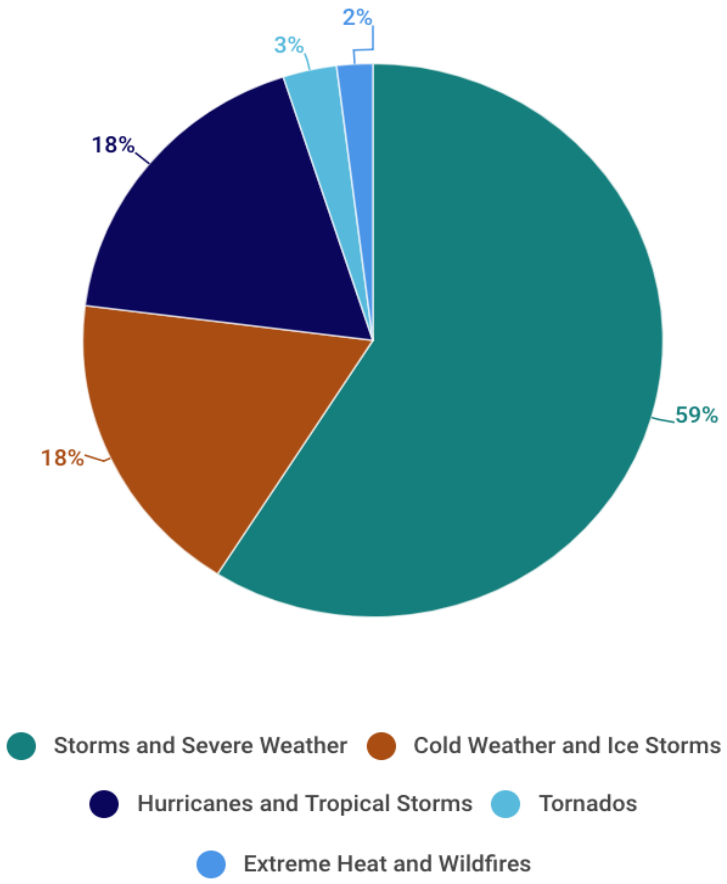
Human error was also responsible for the Southwest Blackout of 2011. An Arizona Public Service employee switched out parts of monitoring equipment and sent sections of California, Arizona, and Mexico into darkness during peak hours, closing airports, shutting down the San Diego tram system and clogging freeways during rush hour. Plus, millions of residents and companies were without lights or air conditioning during one of the hottest times of the year.

Energy customers themselves can also be the cause of power outages. For example, every year around Valentine's Day, Pacific Gas and Electric (PG&E) warns customers not to release shiny, metallic balloons, a popular gift for the holiday, into the air around electric wires because they can pose a hazard to electric lines. In 2017, gifts like these caused 456 power outages that disrupted electric series to over 371,000 homes and businesses. This was an increase compared to prior years. In 2016, metallic balloons were responsible for 429 outages, and in 2015, they were responsible for 370.

While human error and energy customers can cause detrimental power outages, the biggest threat to electricity-reliant societies is natural.

Between 2003 and 2012, 147 million customers, comprised of households, commercial businesses and industrial business, were affected by weather-related power outages. And, according to a 2013 report by the U.S. National Climate Assessment, that number is expected to increase with each year as extreme weather events are becoming more frequent and intense.

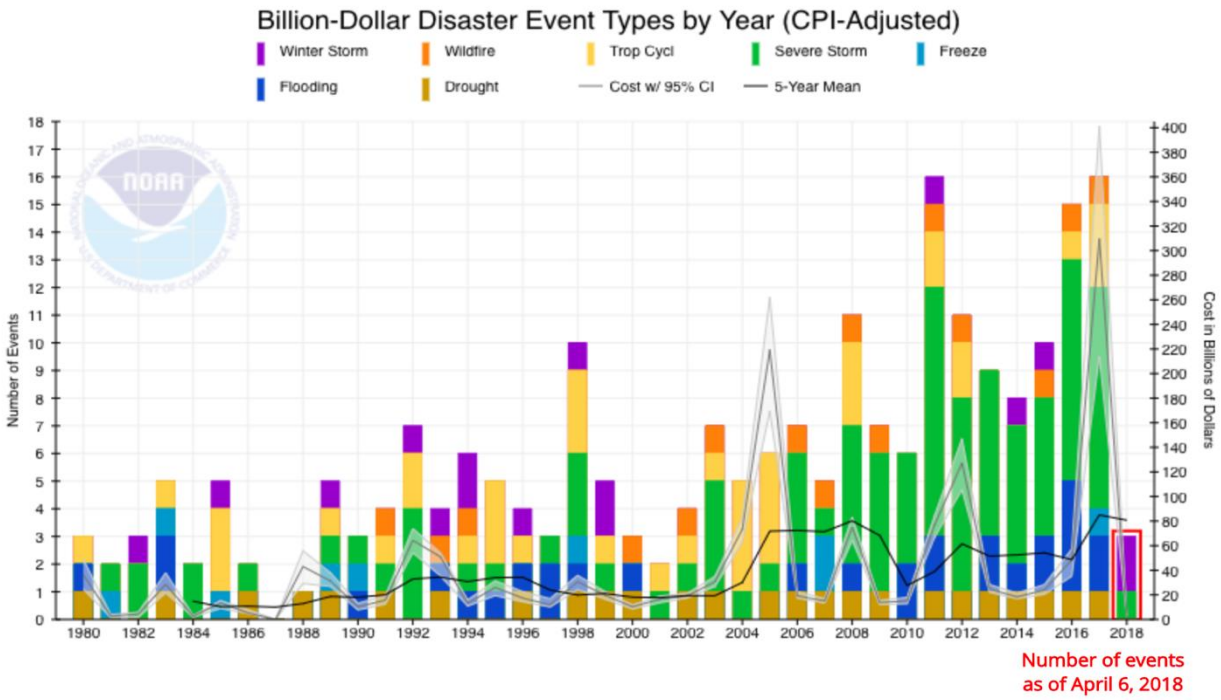
Figure 1 — Breakdown of Weather-Related Outages Between 2003 and 2012



Source: Climate Central

Figure 2 breaks down different types of disaster events with the frequency they occurred and the cost of each event. Not only are these events costing more over time, but they are also happening more regularly.

Figure 2 — Extreme Weather Events over Time



Source: U.S. NOAA NCEI (2018a)

As warmer weather approaches each year, heat waves and wildfires become more of a concern. The National Climate Assessment noted that heat waves are now longer and harsher. The western states have seen more heat waves during the 2000s than any previous century. Heat waves can cause increased demand for air conditioning, which can create a strain on electrical equipment, and in turn result in power outage.

Plus, wildfires have been steadily increasing over the past forty years. The 2017 California wildfire season was the "largest and most destructive" fire season on record. Power lines were found to be the cause of at least a dozen of these fires and utilities in California now have plans to deenergize the electric grid for days at a time when they deem the fire risk to be too high.

On the other hand, winter storms can cause power outages too. Cold weather and ice storms were responsible for about 18 percent of outages between 2003 and 2012, and trends are showing that winter storms have "increased in both frequency and intensity."

However, the majority of weather-related outages are caused by storms and severe weather year-round. Trends show an increase in heavy downpours and flooding throughout the country. In fact, insurance companies are paying around seven times more for severe thunderstorm damage now than they were in the late 20th century.

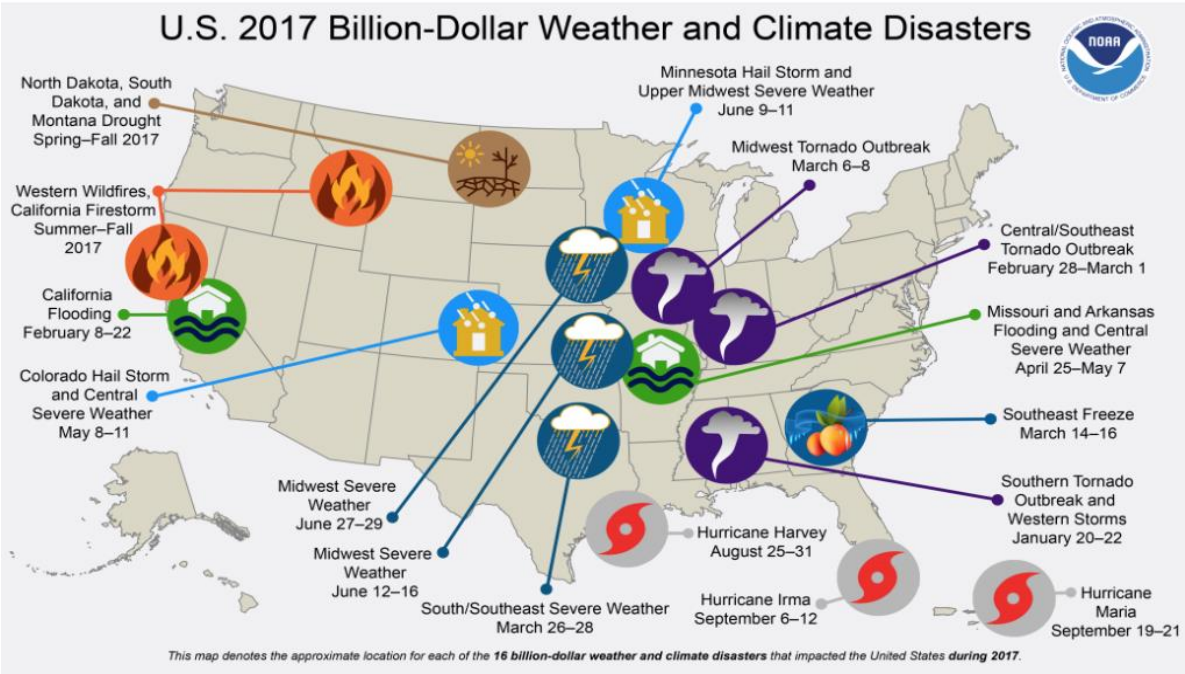
While the total amount of precipitation is increasing across the United States, heavy rain is most dramatically affecting the Midwest and the Northeast. The precipitation falling in the Northeast has increased by 74 percent, and the Midwest has experienced a 45 percent increase. Not to mention, both areas are experiencing 30 percent more heavy downpours than in the 1960s. Even with light winds, trees and branches fall as saturated soils can't hold.

On the coastal regions of the United States, more intense hurricane seasons have become a major issue. Hurricanes are responsible for 18 percent of weather-related outages. For example, Hurricane Sandy ripped its way through 24 states, including the most populated city in America, in late October of 2012. Hurricane Sandy became the second most costly hurricane in American history, and the damages totaled to around $65 billion.

Power outages were a major issue in the areas affected by Sandy. In total, 8.5 million customers were without power. About 200,000 small businesses and 30 residential care facilities were closed due to power outage. And every open New Jersey hospital relied on emergency generators to make it through the storm. After the storm, around 48,000 trees were removed or trimmed to restore power, and in New Jersey alone, it cost $1 billion to repair power lines.

Figure 3 shows the 16 extreme weather events whose damage exceeded $1 billion in the last year. In just one year, the country experienced eight different types of costly weather disasters spread throughout the country. The total cost for just these events totaled over $350 billion.

Figure 3 — Various Extreme Weather Events in 2017



Source: U.S. NOAA NCEI (2018a)

While weather might be the most prevalent threat, cyberterrorism could be the risk with the most detrimental effects. Because American society is so reliant on electricity, the loss of power could be considered one of the country's biggest national security hazards. These attacks have extreme potential to devastate the country and are, unfortunately, increasing in frequency.

In 2016, an Idaho National Laboratory reported that power companies expressed a "six-fold increase in the number of detected cyber incidents" compared to prior years. The Tennessee Valley Authority (TVA) reported that in 2016, "almost 14 billion cyber events were visible against TVA operating technology, of which 491 million were classified as potential security events and more than 54,000 required additional actions."

Even Rick Perry, the Department of Energy Secretary, stated that he's "not confident" in the grid's security from attacks. This statement came in response to a government report about Russian hackers attempting to infiltrate America's "critical infrastructure."

Other analysts report similar findings, such as other nations having the "capability to shut down the U.S. power grid, potentially causing power outages across large portion of the grid for days or weeks."

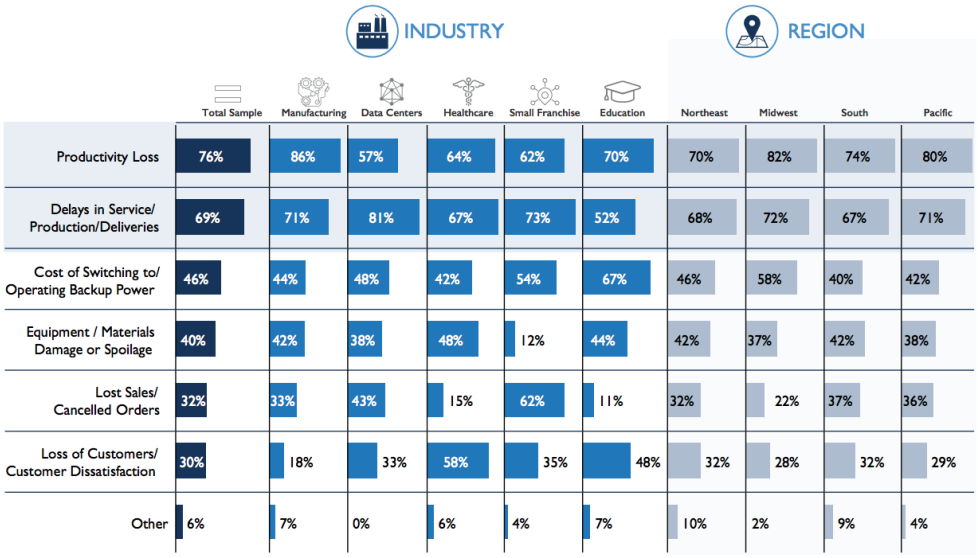
Power Outage and Your Business

Electricity is vital for any and every business. So, threats to the grid also become threats to your business.

Within the next 12 months, nearly 70 percent of businesses will experience at least one power outage. And downtime caused by outages are becoming increasingly expensive making energy resilience vital to keeping businesses in business.

Disruptions have immediate effects such as lost sales, supply chain disturbances, or patient care disruption. In addition, power outages can have long-term effects on business reputation and reliability status.

Figure 4 — Impacts of Power Outage, 2017



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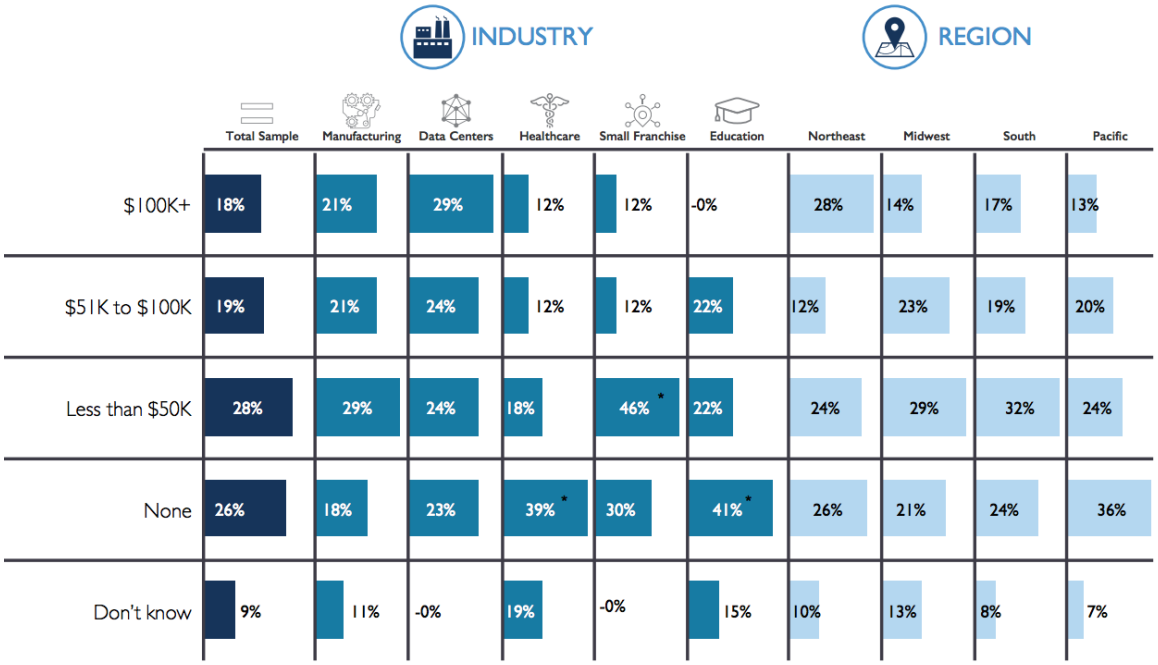
A12. The following are possible types of impact that your company may have experienced due to power outages in the past 12 months. Please select the 3 most significant types of impact that your company experienced. - Ranked

Source: S&C

Figure 4 breaks down the different type of impacts and the rate at which businesses report experiencing them. Over 76 percent of businesses experience productivity loss, and 69 percent report delays in service, production and deliveries across all industries. Electric grid outages are expensive, and their economic impact can be seen in every state. Businesses located in populated, coastal area are hit especially hard by outages. For example, Texas, New York, and Florida each lose between $7 billion and $12 billion of economic activity annually due to power loss, and California experiences over $18 billion lost per year. Even landlocked states do not escape costly outages and can lose around $4 billion annually from outages.

As shown in Figure 5, when businesses across the country were surveyed on the financial impact of their single worst power outage they had that year, 18 percent reported just one outage costed over $100,000, and 19 percent reported a financial impact of over $50,000. It is important to note that 21 percent of these businesses reported experiencing at least one outage per month. It is easy to see how power outages can add up.

Figure 5 — Financial Impact of Company's Worst Power Outage, 2017



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A8. What was the financial impact to your business because of this single event?
** Significantly larger at 95% confidence level*
Source: S&C

Around 70 percent of businesses report power reliability being a concern for their company. Similarly, over 50 percent feel dissatisfied with the current state with the reliability of their power provider, with the most common reason for dissatisfaction being "too many outages." Businesses need to find a way to protect themselves from costly power outages, especially since outages are predicted to increase due to grid vulnerability.

How to Address the Problem

The need for continuous power has created a demand for higher resiliency and a backup power system protects businesses from natural hazards, physical threats and other areas of vulnerability. Backup generation allows businesses to function without disruption, despite the growing vulnerability of the grid.

Resiliency during Hurricane Harvey

Hurricane Harvey hit the Gulf Coast of Texas on Aug. 25, 2017 as one of the most destructive storms in U.S. history. The aftermath of the storm left nearly 30,000 people displaced, and it destroyed more than 200,000 businesses. It is estimated that Harvey cost Texas $125 billion in damages.

Throughout the duration of the storm, ERock powered 18 HEB grocery stores and three Buc-ee's travel centers, providing 100% reliability for over 105 consecutive hours.

While most stores in the area were closed, HEB and Buc-ee's were able to remain open and serve their community thanks to backup generation.

Not only did the backup generation prevent these 21 stores from losing revenue and refrigerated inventory, more importantly, it increased customer trust and loyalty.

Backup power can benefit businesses in a multitude of ways. Businesses with energy resiliency plans are 24 percent more likely to report a strong financial performance, 15 percent more likely to report a good brand reputation and 27 percent more likely to consider themselves in a good position for future success.

Businesses have a number of backup power options to choose from. However, not all the choices present the same level of reliability.

Historically, diesel has been the choice for backup power fuel with on-site storage commensurate with the expected outage frequency and duration. However, during extreme weather events, there can be shortages of the diesel fuel and delivery routes can be impassable limiting the effectiveness of diesel backup generation. This was the case during Hurricane Harvey in Houston, Texas when the storm shut down refineries and the

ports used to transport the fuel. Diesel is also a major contributor to environmental pollution problems.

Unlike diesel, fuel cells are quiet and have much lower emissions. Because they run on hydrogen, heat and water are fuel cells only byproducts. However, sites that utilize fuel cells need to be in close proximity to hydrogen distribution facilities or use natural gas reformers to produce hydrogen locally. In any case, the cost of fuel cells is still prohibitive in all but select market niches without government incentives.

Another option is combined heat and power (CHP). Like fuel cells, CHP is a more ecological method of power. CHP systems use waste energy from power generation to meet thermal needs. The cost of CHP-style on-site generation can be impacted by utility tariffs and standby rates, which can make it a less-economical choice. The CHP systems themselves are rather costly per unit of capacity, which can be capital intensive for businesses.

A new, up-and-coming backup power source is combining solar photovoltaic (PV) systems with battery energy storage. The costs of both of these technologies have been decreasing, and PV produces clean energy. However, PV assumes that there will be "enough solar resource" and battery capacity to meet the load during outages that can extend well past the typical daily change and discharge cycle. PV plus storage can also require an additional cost to allow the system to island, which is a key component of a resilient system.

Natural gas is becoming an increasingly popular choice for businesses. The abundance of and ability to store natural gas underground allows it to be a cheaper and more reliable alternative to other sources of fuel. It also produces less carbon then other fossil fuels, allowing it to be an environmentally sensible option compared to diesel.

Enchanted Rock's natural gas-powered backup generators at a Texas grocery store.

Currently, there are more than 500,000 wells in 30 different states producing gas. Natural gas is transported primarily through underground pipelines, which remain safe during extreme weather events. Even if there is a disruption to the gas service, the system can reroute flows and offset the problems.

In conclusion, electricity is becoming more and more important to our fast-paced, digital society. In order to keep up with the demand of continuous power, businesses must protect themselves from the harms caused by grid vulnerability by being equipped with one of the many forms of backup power. Electricity is not sufficiently reliable, so it is imperative that businesses to take action to ensure their own business resiliency.

About Enchanted Rock

Enchanted Rock provides clean and affordable long duration backup power to commercial, industrial, and institutional customers by delivering a proven, full-service solution with the cleanest available technology. Enchanted Rock handles the design, construction, commissioning, operations, and maintenance of natural-gas powered generators so utilities can provide their customers with reliable backup power without the expense and challenges that come with maintaining a backup generation system. To learn more about offering electrical resiliency using Enchanted Rock solutions, visit www.enchantedrock.com.

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