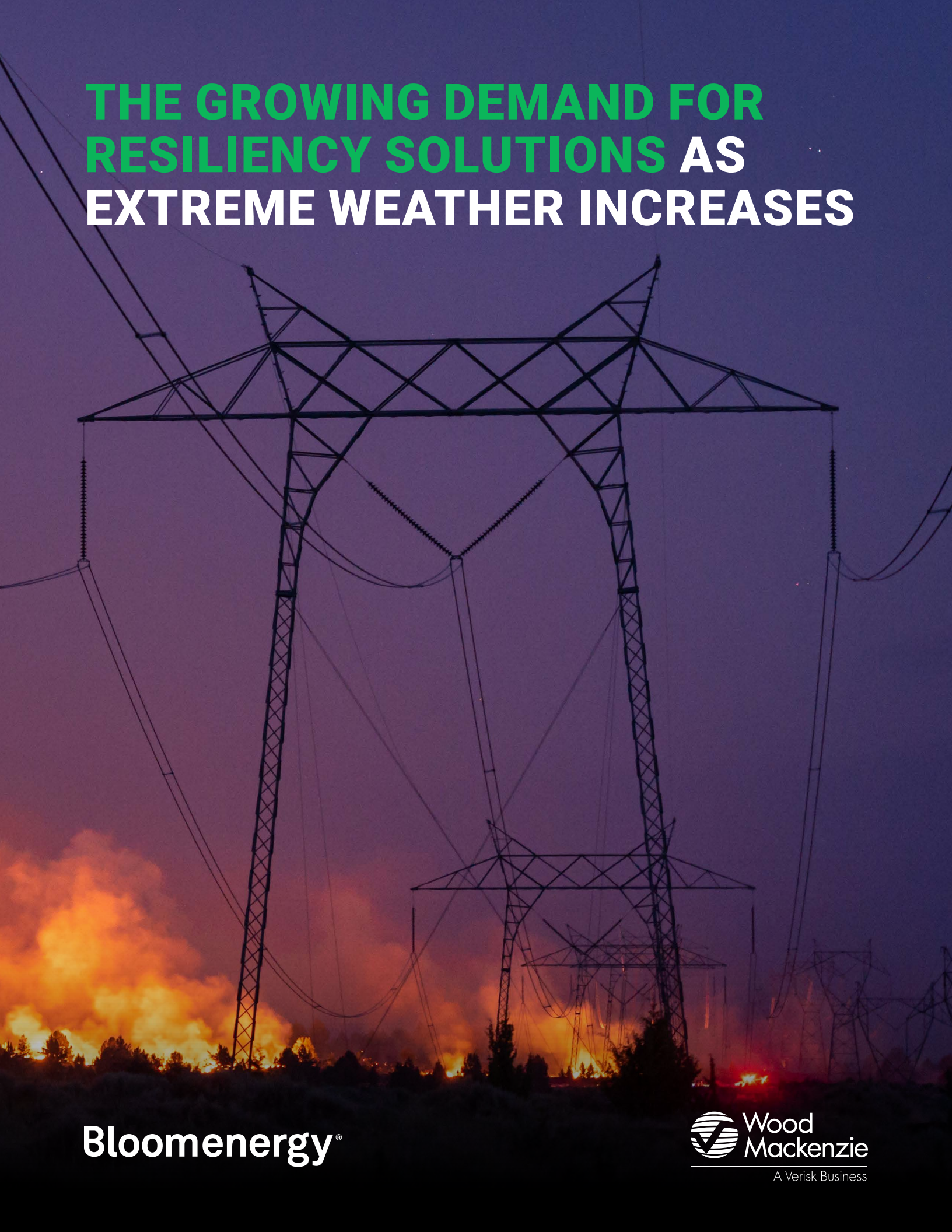
THE GROWING DEMAND FOR RESILIENCY SOLUTIONS AS EXTREME WEATHER INCREASES



Bloomenergy®

Wood Mackenzie
A Verisk Business

The history of 2020 and 2021 will always be defined by the coronavirus pandemic. The COVID-19 virus upended families, communities, businesses, and societies – the most tragic impact being the terrible loss of life and illness the disease inflicted around the world.

The COVID-19 outbreak also reminds us how globally interdependent society is, revealing just how vulnerable we are to disruptions that impact the production and distribution of goods and services. Communities and businesses are also learning that they must be locally resilient to survive.

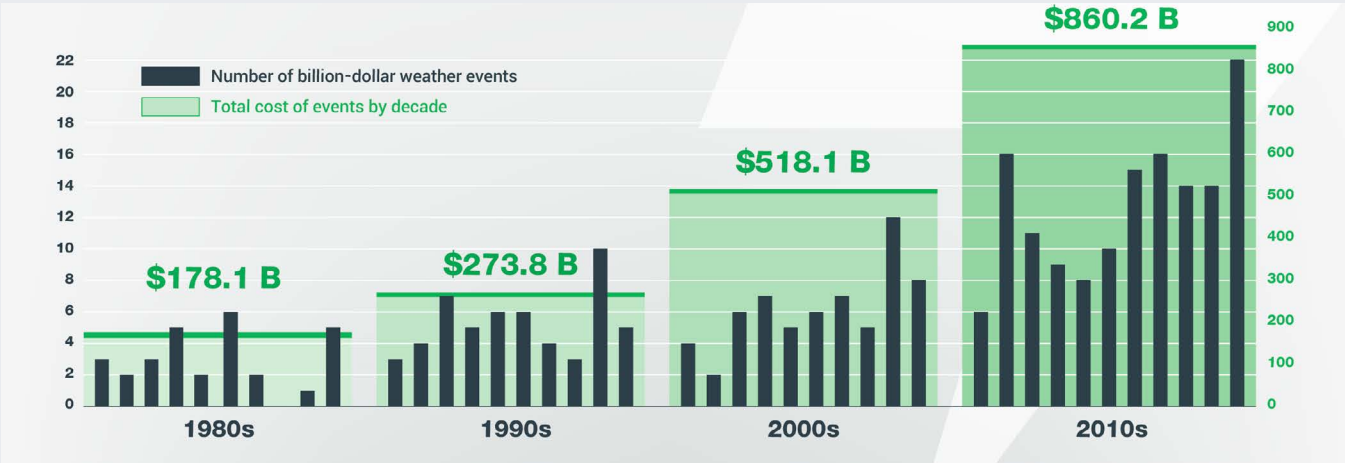
Localizing critical services such as food and hardware supplies, as well as medical and manufacturing services, is necessary to serve communities when global supply chains are disrupted. Just as these critical services must be localized, so must electricity, which is why businesses and communities are implementing localized microgrids to supply reliable and resilient electricity.

Even as the world continues to learn lessons from COVID-19, the growing negative impacts of climate change on the welfare of people, communities, and the economy only became more obvious. Indeed, the increasing severity and frequency of extreme weather events were impossible to avoid. So too were their cascading effects on foundational pillars of society, particularly the power system.

According to the National Oceanic and Atmospheric Administration (NOAA), the U.S. experienced a record 22 weather and climate events whose costs totaled $1 billion or more in 2020. The events ranged in both type and in the regions impacted, ranging from wildfires across the Western U.S. (which continue today) to seven tropical cyclones, three tornados, and 10 severe weather events, including hailstorms in Texas and the Midwest derecho.

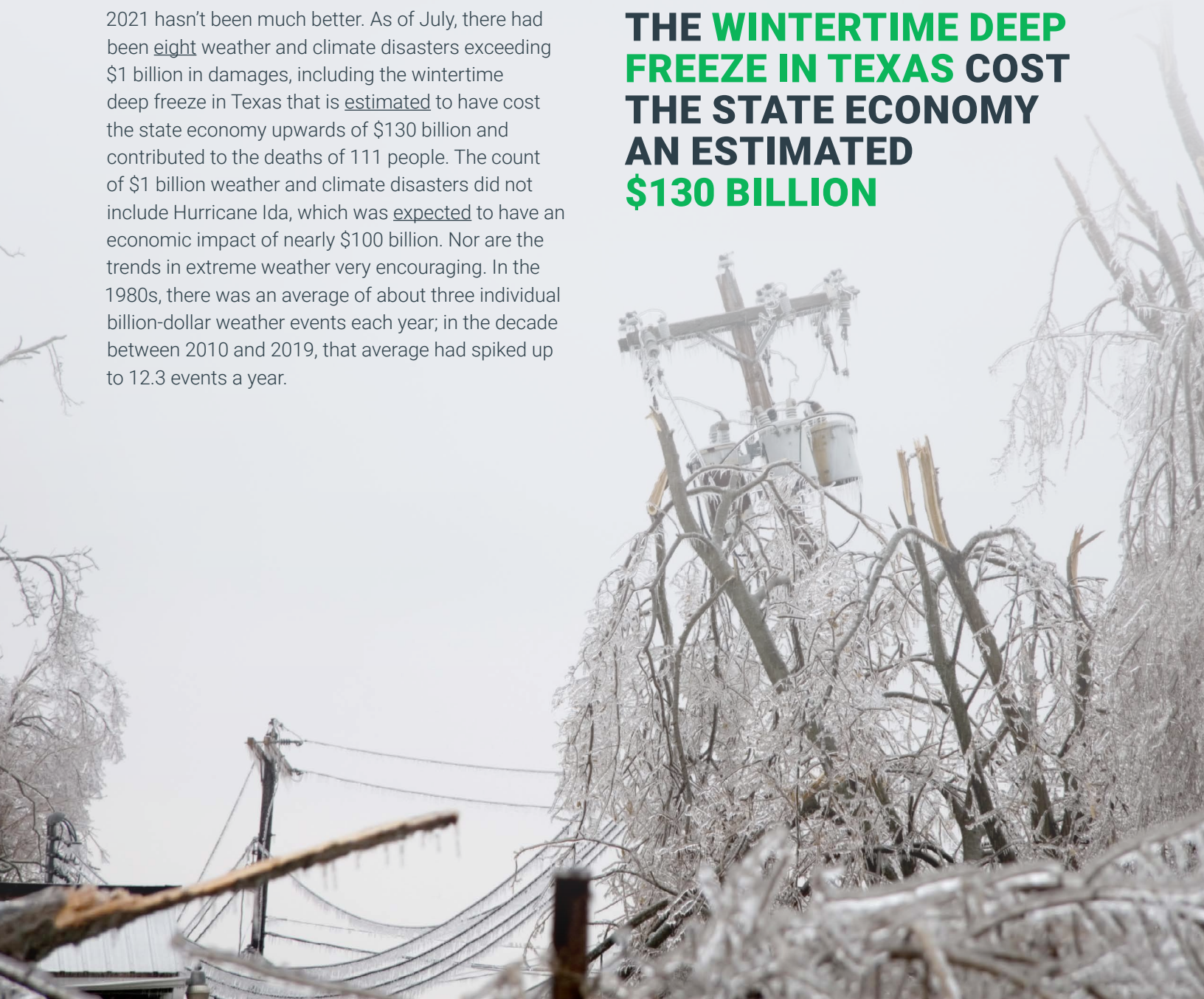
THE U.S. EXPERIENCED A RECORD 22 WEATHER AND CLIMATE EVENTS WHOSE COSTS TOTALED $1 BILLION OR MORE IN 2020.

A day without power - Through the decades: Billion dollar weather events



2021 hasn't been much better. As of July, there had been eight weather and climate disasters exceeding $1 billion in damages, including the wintertime deep freeze in Texas that is estimated to have cost the state economy upwards of $130 billion and contributed to the deaths of 111 people. The count of $1 billion weather and climate disasters did not include Hurricane Ida, which was expected to have an economic impact of nearly $100 billion. Nor are the trends in extreme weather very encouraging. In the 1980s, there was an average of about three individual billion-dollar weather events each year; in the decade between 2010 and 2019, that average had spiked up to 12.3 events a year.

THE WINTERTIME DEEP FREEZE IN TEXAS COST THE STATE ECONOMY AN ESTIMATED $130 BILLION



Extreme weather, an aging grid, and increasing outages

The extreme weather of 2020 corresponded with a rising number of power outages. According to PowerOutage.US, an aggregator of utility blackout data, there were 1.33 billion outage hours in 2020. That number is up 73 percent from 2019, when U.S. utility customers endured 770 million outage hours. The pain of these power outages spread throughout the country, with Louisiana leading the nation with 181 million outage hours. California, which suffered another year of severe wildfires in 2020, had over 103 million outage hours.

The increasing number of power outages takes a very human toll on people who have to endure severe cold or scorching heat without electricity – a situation that particularly imperils the health of the elderly and other vulnerable people. Outages also take an economic toll, as businesses are forced to close down operations or cease manufacturing.

The impact of outages on businesses also harms communities, as companies are no longer able to supply the food, water, medical, and other emergency services citizens need most during times of crisis.

For example, S&C Electric Company's 2021 State of Commercial and Industrial Power Reliability Report surveyed 253 C&I companies with annual revenues averaging $75 million. The report found:

- There was a large increase in short-duration outages between **2019 & 2020,** a jump from **20% TO 40%** and that 44 % of companies surveyed lost power monthly or more frequently.
- The majority of companies reporting monthly outages reported that the loss of power cost them **$1.2 MILLION ANNUALLY.**
- Overall, the Department of Energy (DOE) estimates that power outages cost the U.S. economy **$150 BILLION ANNUALLY.**

While the increase in power outages is undoubtedly connected to the proliferation of more extreme weather events, another contributing factor is America's aging power grid. The American Society of Civil Engineers (ASCE) recently gave the U.S. grid a C- grade in its 2021 Infrastructure Report Card. A big reason for the low grade is the fact that much of the transmission and distribution grid was built in the 1950s and 1960s with an expected lifetime of 50 years. In California, some transmission towers are 108-years-old and their average age is 68.

Put simply, an aging grid is more vulnerable to outages caused by extreme weather. And utility initiatives to harden the grid against extreme weather are expensive, costs that will ultimately be passed down to ratepayers. For example, in July Pacific Gas & Electric (PG&E) in California announced a plan to bury 10,000 miles of power lines in an effort to reduce the risk of wildfires. The price tag for undergrounding distribution and transmission lines: Between $15 billion and $30 billion.

A growing demand for microgrid resiliency solutions

Given the growing threat of extreme weather and the importance of limiting or eliminating outages, it's no surprise that an increasing number of businesses and communities are exploring new resiliency solutions.

Significant attention is being paid to the potential that microgrids have to improve resiliency and reliability. Microgrids can be made up of a variety of assets, including fuel cells, batteries, solar, and generators, providing a decentralized power system that can disconnect and operate independently from the main grid in the case of planned or unplanned grid outages. Microgrids also have the benefit of providing local power near where it is consumed, helping to eliminate the vulnerabilities of the transmission and distribution infrastructure.

Proof that more businesses and communities are exploring and implementing microgrids to bolster resiliency comes from the fact that Wood Mackenzie Power and Renewables (WoodMac) is currently tracking over 3,600 planned and operational microgrid projects across the United States.

Household brands and blue-chip companies already have installed microgrids at some of their sites.

Individual end users by segment

Retail/Service

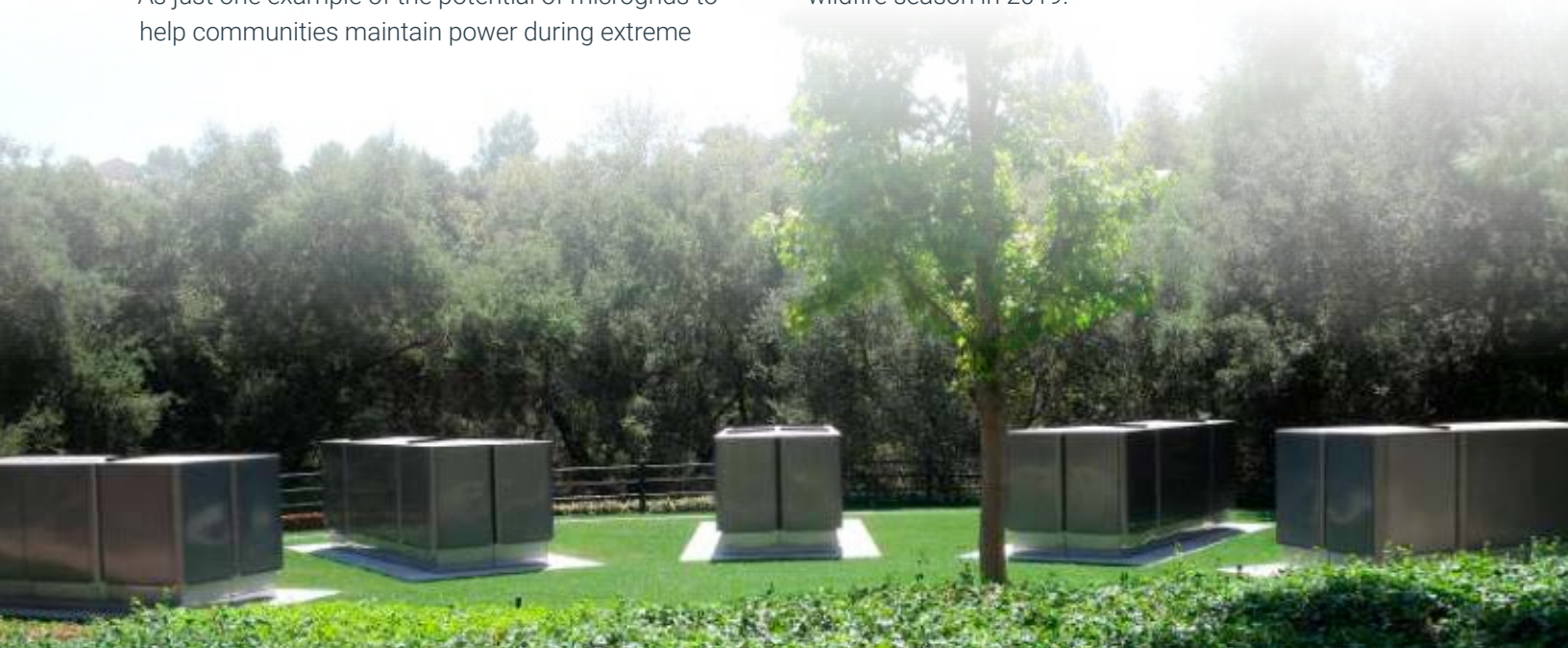
Healthcare

Industrial: Manufacturing

Industrial: Agriculture

Technology/Data

In addition, WoodMac forecasts that microgrid deployments will reach an all-time high in 2021 and will likely surpass 800 megawatts over the next three years. As just one example of the potential of microgrids to help communities maintain power during extreme weather events, The Washington Post profiled the Blue Lake Rancheria Native American tribe's ability to keep the lights on with a microgrid during California's intense wildfire season in 2019.



Commercial and industrial customers have grown from 2016-2019

Policy is also moving to support microgrid development. Earlier this year, California Congressman Jimmy Panetta introduced legislation whose name said it all: The Making Imperiled Communities Resistant to Outages with Generation that is Resilient, Islandable, and Distributed (MICROGRID) Act. The bill would establish a 30 percent tax credit for the development of microgrids through 2025.

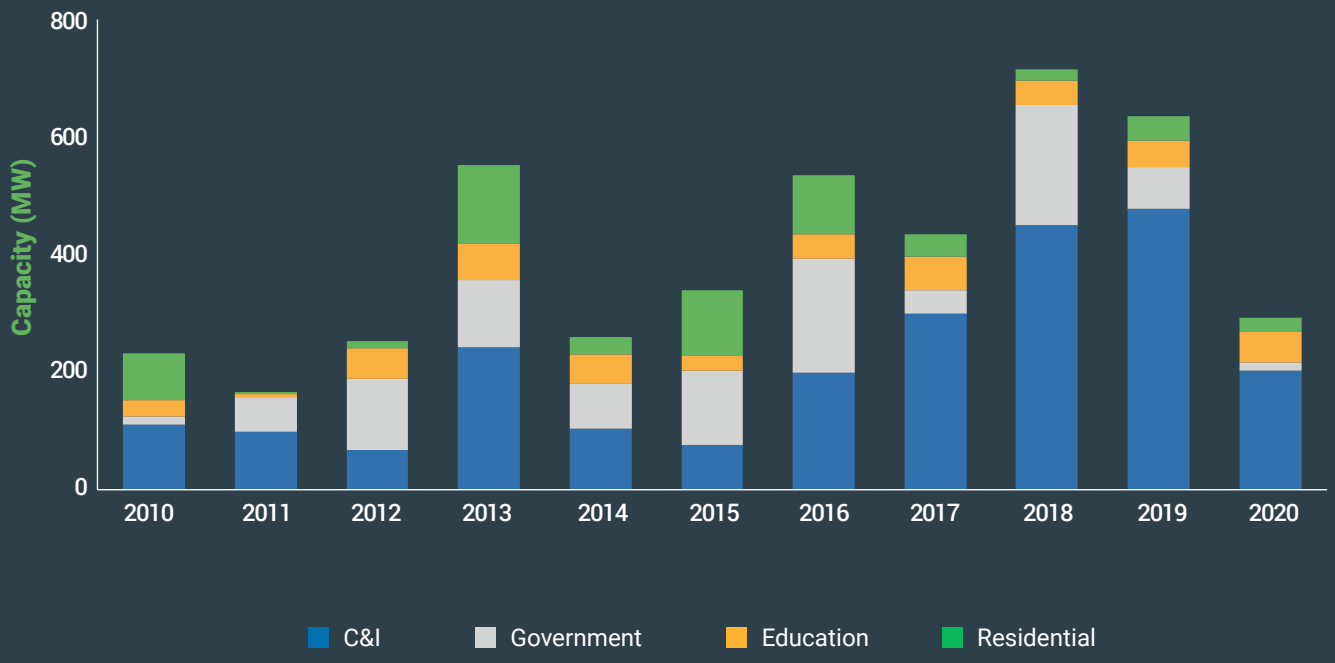
3,600 PROJECTS

WoodMac is currently tracking over 3600 microgrid projects across the US.

800 MEGAWATTS

Microgrid deployments will surpass 800 megawatts over the next three years.

Annual microgrid deployment by end-user segment



Source: Wood Mackenzie

An unsustainable, unpredictable, and unreliable status quo

The attention being paid to microgrids by businesses, communities, and policymakers is also an indication that existing solutions that provide backup power have significant drawbacks. Indeed, hospitals, data centers, factories and a range of other customers are not new to the idea that resiliency is critical. Traditionally, backup power has been provided by a combination of uninterruptible power supply (UPS) and diesel generators.

Climate and environmental concerns are driving the search for cleaner backup power alternatives. In part, that is driven by the public commitments that corporations and communities themselves have made. For example, over 300 corporations around the world have made a commitment to power their businesses with 100 percent renewable energy while over 180 U.S. cities have made the same pledge. Relying on diesel generators for backup power during extreme weather events fueled by climate change runs counter to those objectives.

Microgrids offer a pathway to simultaneously improve resiliency while making significant progress towards sustainability goals in a way that diesel generators simply can't. Though the amount varies by machine type, diesel generators not only emit large amounts of carbon dioxide, the exhaust they produce also includes over 40 toxic air contaminants, including many carcinogenic compounds. In response to this summer's extreme weather conditions, California Governor Gavin Newsom issued an emergency proclamation suspending permitting and regulations limiting the use of backup power generators. The use of diesel generators had already risen dramatically over the past three years, due to grid outages.

Recent studies demonstrate the environmental benefits of certain microgrids over diesel generators as a backup power solution. For example, a 250-kilowatt diesel generator analyzed in Maryland emitted 1,542 pounds of carbon dioxide per megawatt-hour. By contrast, a 250-kilowatt Bloom microgrid emitted 756 pounds of carbon dioxide per megawatt-hour and virtually zero nitrogen oxides (NOx) and sulfur oxides (SOx).

Environmental and health impacts aren't the only problems with diesel generators. As companies and communities more aggressively pursue decarbonization and sustainability goals, there is a high level of risk that existing dirty backup power solutions will become stranded assets. But perhaps even more important is the risk that diesel generators won't actually provide the backup power that's so desperately needed during extreme weather events.

Even as extreme weather events increase, the reality is that backup power is not needed very often; most diesel generators sit idle 99 percent of the time. That inactivity means that expensive monthly maintenance and testing are required to ensure that diesel generators will operate as needed when a power outage occurs. This is a real problem: According to the American College of Emergency Physicians,

16 PERCENT OF EMERGENCY MEDICAL SERVICES ORGANIZATIONS REPORTED THAT DIESEL GENERATORS DID NOT PERFORM AS EXPECTED DURING HURRICANE SANDY

Even when diesel generators start as expected, failure rates rise if an outage lasts for longer than one day. In cases when outages are extended, the availability of fuel can also be a problem, particularly when enough diesel fuel isn't already stored on-site and has to be delivered. In those emergency situations, access to scarce fuel will inevitably be prioritized, with hospitals, fire and police stations and other essential services receiving fuel first.

How to evaluate resiliency solutions

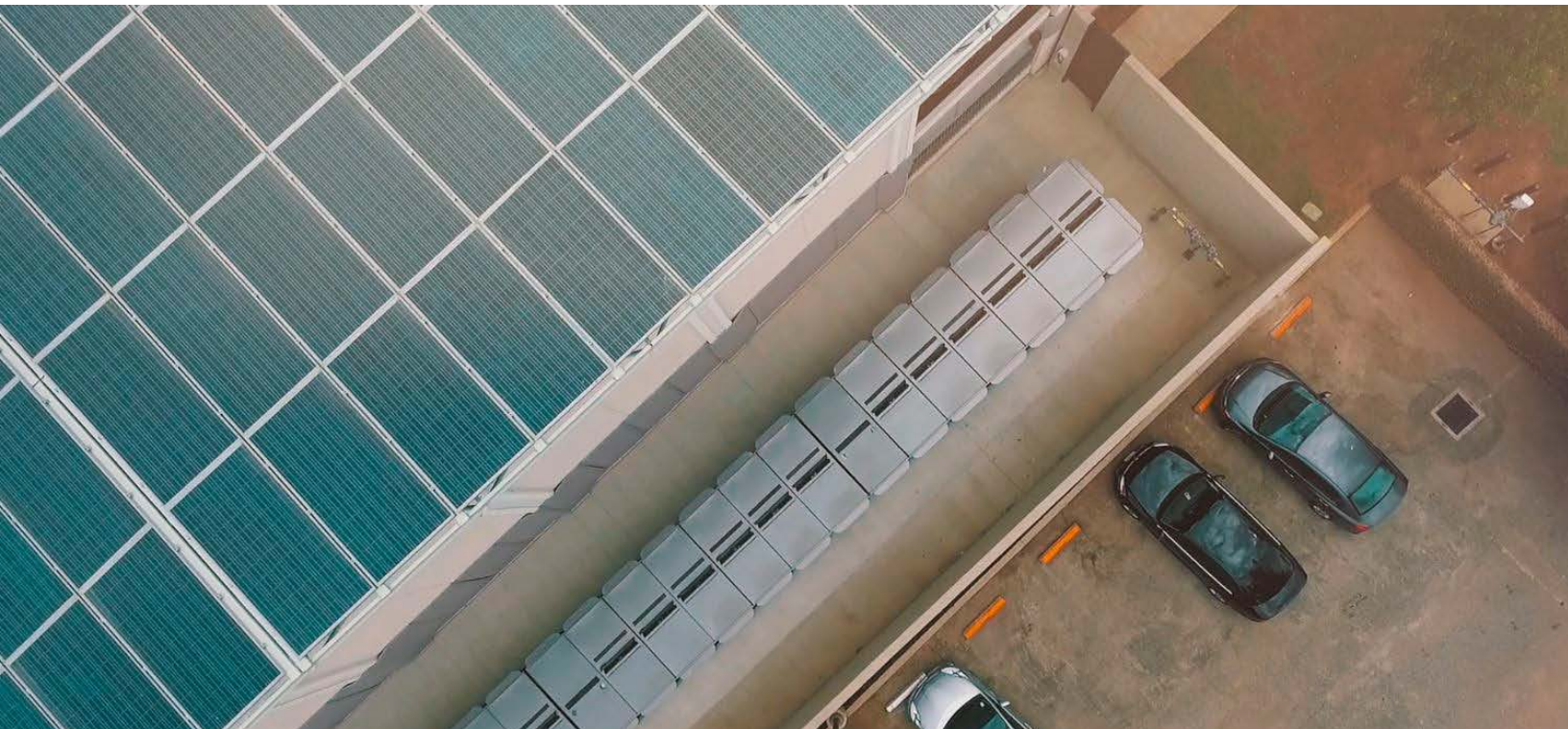
It's understandable that customers considering microgrids as a resiliency solution compare them to backup power supplied by UPS and diesel generators. But microgrids – especially those that include solid oxide fuel cells, which we discuss in more detail below – are fundamentally different from traditional backup power solutions.

The main difference is the fact that microgrids that utilize solid oxide fuel cells have the capacity to provide "always on" power. Let's unpack what that means. Among the vulnerabilities that a business or community has when they rely on a diesel generator to kick in during a power outage is that it won't make the switch from grid power to backup power and that power quality will suffer.

That is simply not an issue with microgrids that use fuel cells; the microgrid is constantly supplying power before a grid outage and continues to do so after a power outage occurs. From an economic perspective, always-on microgrids allow customers to avoid unpredictable utility rate increases. Microgrids also help companies avoid the steep costs of an outage on their business operations because microgrids can maintain power over long periods of time. Put even more simply, always-on microgrids eliminate the need for backup power altogether and provide continuous value rather than assets that are used only intermittently and may or may not work.

Always-on power also allows for price predictability. A microgrid can be provided to a customer as a service, meaning that its installation and operation and maintenance are the responsibility of a third-party provider like Bloom Energy. When that happens, the customer will have a set price for electricity delivered over the duration of a contract, typically 15 years. By contrast, the price of power from the grid is anything but predictable, with utility rates forecast to rise for the residential, commercial, and industrial sector.

For example, California's Pacific Gas & Electric (PG&E) utility proposed a plan to bury 10,000 miles of its power lines in an effort to reduce wildfire risks. The project is estimated to cost between $15 billion and $30 billion. The potential price impact of these and other investments would be $1 per day, or about a 5 percent annual bill increase. Overall, the U.S. Energy Information Administration (EIA) reports that commercial rates in California, Oregon, and Washington increased from 14.5 cents per kilowatt-hour in May of 2020 to 15.16 cents per kilowatt-hour in May of 2021.



BUT INDIVIDUAL CUSTOMERS NEED TO EVALUATE RESILIENCE SOLUTIONS BASED ON THEIR UNIQUE NEEDS AND OBJECTIVES AROUND PREDICTABILITY, COST, AND SUSTAINABILITY.

A FEW QUESTIONS TO HELP GUIDE THE CONSIDERATION OF RESILIENCY SOLUTIONS INCLUDE:

How important is power quality?

A significant factor in selecting a resiliency solution is how much of a priority power quality is to your operation. We define power quality as an uninterrupted perfect waveform of electrons. The answer to that question depends on how you actually use electricity. Many companies and communities have mechanical equipment like air conditioning units that can turn off and back on without creating any problems. For others, like data centers and semiconductor manufacturers and laboratories, even a half second of power interruption can have grave consequences. Understanding which critical loads must have uninterrupted, high-quality power for long periods of time is a good starting place.

Which loads do you need to cover?

Not all loads are critical. A logical follow-up question to the importance of power quality is to prioritize the loads you want to keep running if there is a grid outage. For a data center, the answer to this question is obvious: All loads need to run 24/7, with no interruptions. But for a retailer, the answer can be very different. In the case of a grocer, it may be important to keep cold storage running during an outage while all but a few lights and only a portion of the typical air conditioning units are needed until grid power returns. Establishing these priorities is essential in sizing a microgrid, which determines its cost. The answer to this question must also include consideration of how much grid power you want to rely on overall. Do you see grid power as a backup solution or providing the vast majority of electricity throughout the year?

How long of an outage do you need to cover?

A microgrid can be a primary source of power and provide electricity that is cheaper, cleaner, and more reliable than the grid. But it can also be a supplier of backup power during times of a power outage. Sizing a microgrid and comparing it to other resiliency solutions necessarily involves understanding how long of a power outage you need to prepare for. Are you looking to cover multiple days or just a few hours?

The Bloom Energy Server: A solid oxide platform and why fuel cells ensure resilience

Not all microgrids are the same. By their very definition, microgrids are a collection of assets, including solar, storage, wind, and fuel cells. Selecting the optimal collection of assets in a microgrid is an important task when it comes to ensuring resiliency.

For instance, solar and batteries are important components of many microgrids. But they also can have limitations if they are the primary building blocks. For instance, to achieve a high level of resilience, a system relying on solar and batteries will have to be sized to meet critical loads even when the sun is not shining. That can require a lot of batteries and solar and be an expensive proposition. It can also be impractical or impossible in densely packed urban areas where space is at a premium.

By contrast, the Bloom Energy Server is the foundation of an economic, resilient, and sustainable microgrid. Bloom's Energy Server is a platform that uses solid oxide fuel cells to deliver combustion-free, always on power with low or no carbon emissions. The solution is also cost-effective.

While microgrid design is determined by customer needs and objectives, what allows the Bloom platform to provide such a high level of resilience is the fact that it is anchored with solid oxide fuel cell technology. At a very basic level, the fuel cells create electricity through an electrochemical reaction that utilizes fuel and air – and importantly, doesn't involve combustion that generates air pollution like nitrogen oxides (NOx) and sulfur oxides (SOx), which can lead to harmful respiratory, heart, prenatal, and other health issues.

Where the fuel used in fuel cells comes from is especially important to understanding why Bloom microgrids are so reliable, and why they can help microgrids decarbonize even more in the future. Put simply, fuel cells run on hydrogen. Today, that hydrogen comes into the fuel cells via the ultra-reliable natural gas (CH_4) grid. The natural gas grid is buried underground, meaning that it is nearly impervious to extreme weather events of all types. Bloom fuel cells provide primary power to the facilities they serve. The electric grid becomes the backup, so in the unlikely event that there is a disruption to the natural gas network, the electric grid will continue to power the facility.

Already, Bloom fuel cells can generate carbon-free or even carbon-negative electricity when they use biogas that is generated at dairies, landfills, and wastewater treatment facilities. While virtually all of the hydrogen produced today relies on fossil fuels, Bloomberg New Energy Finance (BNEF) forecasts that green hydrogen produced with renewables will become cheaper by 2030. Bloom fuel cells are easily adaptable to run on the green hydrogen that will likely become mainstream in the near future, providing a future-proof asset that can accelerate a company's sustainability targets and help avoid the financial and regulatory risks of stranded assets.

But maybe the most compelling reliability argument for microgrids that combine fuel cells with solar, storage and other assets is how they have performed in actual extreme weather events. During one outage, a Bloom manufacturing customer ran independent of the electric grid for 5.5 days.

Bloom's platform has protected customers from thousands of grid outage events. In total, that means that hundreds of thousands of minutes of downtime were avoided, the equivalent of hundreds of days without power. In 2019, the most powerful earthquakes to hit California struck near Ridgecrest. The quakes resulted in the loss of electricity from the grid. A Bloom system located just nine miles from the epicenter of the quake did not see any disruption in the natural gas network, showing the resiliency of the system.

The specific vulnerabilities posed to businesses and communities by individual extreme weather are difficult to gauge. But what is clear is that the risks to business operations and community wellbeing are increasing and demand the improved, sustainable, and reliable solutions that microgrids anchored by fuel cells can provide.

Recent history and long-term trends both point to the importance of communities and companies pursuing resiliency solutions that protects them from extreme weather and don't contribute to an already significant challenge. Indeed, the most recent report issued by the United Nation's Intergovernmental Panel on Climate Change (IPCC) pointed out that warming of 1.1 degrees Celsius has led routinely ferocious wildfires and floods. The IPCC, along with many other observers, have emphasized the imperative of fast action to limit warming and the damage caused by extreme weather. The deployment of sustainable backup power solutions can be one of those actions.

Interested in learning more or speaking with an adviser at Bloom Energy? Visit www.bloomenergy.com or contact us today at 1 (408) 543-1500 or email us at info@bloomenergy.com

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