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Why, and how, utilities should start to manage climate-change risk

Extreme weather events are exacting a high—and rising—price. Utilities need to devise and implement strategies to adapt.

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The Fourth National Climate Assessment, released in late 2018, stated that climate change was already having noticeable effects in the United States and predicted "more frequent and intense extreme weather and climate-related events," such as floods and hurricanes. For utilities, the assessment concluded, the possibilities were grave: lower efficiency, higher expenses, and more power outages—even as demand for energy rises. And many utilities are not ready. As the assessment noted, "Infrastructure currently designed for historical climate conditions is more vulnerable to future weather extremes and climate change."

The cost of extreme weather is already high, and the frequency and the cost to life and property of extreme weather events has increased in recent years. If such events become more common or intense, as the assessment predicts, the price will be even higher. Even now, some utilities are making investments in long lived assets in risky locations, increasing system vulnerability and balance sheet risk. On that basis, we believe there is a strong case for utilities to start now to take steps on climate-change adaptation. And there are ways for them to do so—for example by strengthening the grid, exploring investments in batteries and microgrids, and working with new partners.

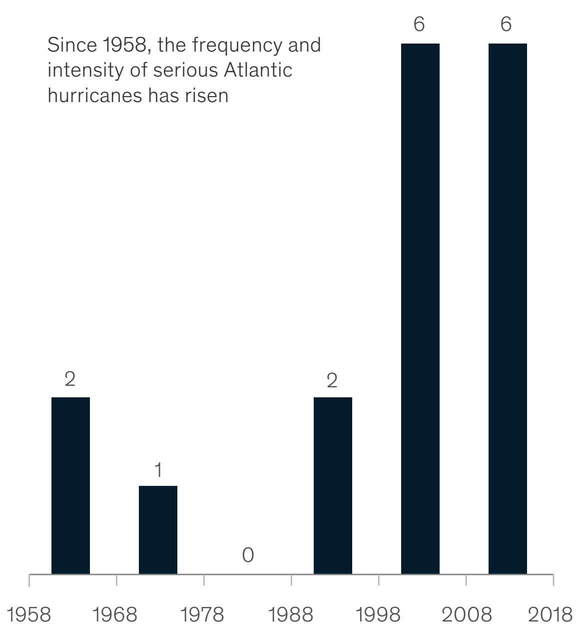
The brewing cost storm for utilities

In 2017, Hurricane Irma made landfall in the Caribbean and Florida. A category 4 and 5 storm, Irma damaged 90 percent of the buildings on the island of Barbuda and caused the fourth-largest blackout in US history. The total cost of damage was $50 billion. And Irma was no outlier. Since 1958, the frequency and intensity of serious Atlantic hurricanes, like Irma, has risen (Exhibit 1).

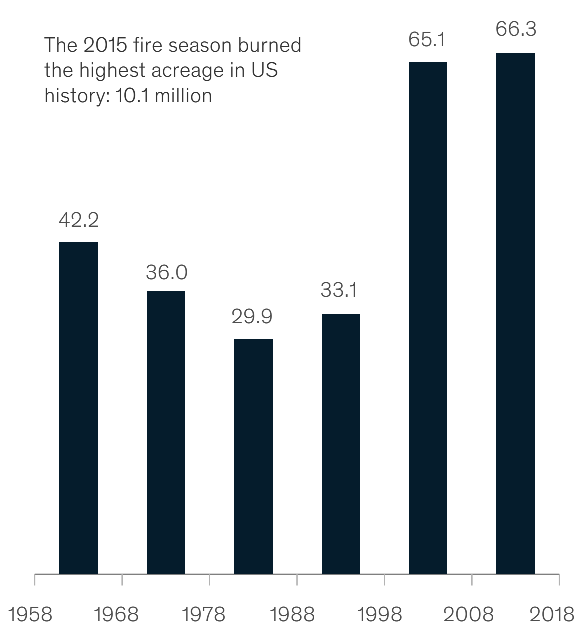
Exhibit 1

Hurricanes and wildfires are getting worse.

Above-average-strength Atlantic hurricane seasons,[1] number per decade



Area burned by wildfires in the US, millions of acres per decade



[1] The National Oceanic Atmospheric Administration uses a metric called ACE, or accumulated cyclone energy, which accounts for the strength, frequency, and duration of all storms in a year, as well as threshold numbers of tropical storms and hurricanes per season, to categorize hurricane seasons into 3 groups: above normal, near normal, and below normal.

Source: National Interagency Fire Center; National Oceanic Atmospheric Administration

In other ways, too, utilities are already more vulnerable to extreme weather events than in the past. When homes are built in areas prone to wildfires, power companies follow, placing their own assets at higher risk. These can even exacerbate the problem, if sparks from power lines ignite. Fires also emit additional carbon dioxide (CO_2), a greenhouse gas that contributes to climate change. In California, the devastating 2018 fire season emitted approximately 15 percent of the CO_2 California emits from all sources in a typical year.

If climate change brings significant sea-level rise, as many models predict, that raises new vulnerabilities, but the risk is material today. In the United States, nine nuclear-power plants are located within two miles of the ocean. Many of the nation's 8,625 power plants were deliberately sited near shorelines in order to have access to water. As a result, when hurricanes strike, power plants already face significant flooding damage.

According to the Department of Energy, 44 power plants were in flooded areas in Hurricane Irene and 69 were in flooded areas in Hurricane Sandy. During these hurricanes, eight nuclear power plants had to shut down or reduce service. During Houston's Hurricane Harvey in 2017, wind and catastrophic flooding knocked down or damaged more than 6,200 distribution poles and 850 transmission structures; 21.4 gigawatts of generation were affected by wind damage, flooding damage, fuel supply issues, or evacuations and shutdowns. If sea levels rise, storm surges would hit further inland, causing more damaging coastal flooding to generation, transmission, and distribution infrastructure.

Unless utilities become more resilient to extreme weather events, they put themselves at unnecessary risk, in both physical and financial terms. Repairing storm damage and upgrading infrastructure after the fact is expensive and traumatic. Hurricane Katrina in 2005 forced Entergy New Orleans into Chapter 11 bankruptcy reorganization. There are, of course, compelling environmental and social reasons to invest in mitigation efforts sooner rather than later. We believe there are also economic ones. Power utilities need to invest on the basis that the present is already riskier than what was planned and the future will be more volatile. There is evidence that climate change adaptation can also be cost-effective.

The benefits of being prepared

In order to understand the economics of mitigating climate-change risk in the United States, we considered the effect of extreme storms, largely hurricanes, on utilities, because it is relatively easy to measure storm-related impacts. To do so, we examined the financial records of ten large power utilities in seven states where hurricanes are common (Alabama, Florida, Georgia, Louisiana, North Carolina, South Carolina, and Texas), plus New Jersey, where hurricanes are less common but dense coastal populations mean damage from storms can be particularly costly.

According to this analysis, a typical utility saw $1.4 billion in storm-damage costs and lost revenues due to outages caused by storms over a 20-year period. Then, using estimates from the Fourth National Climate Assessment for increases in extreme weather events and coastal infrastructure damage driven by climate change, we estimated that by 2050, the cost of damages and lost revenues would rise by 23 percent ($300 million), or approximately two to three additional years with major hurricane damage. (These projected increases are conservative; they are based on estimates of regional increases in extreme weather or storm damage due to sea-level rise.) Combined, these estimates give us a baseline: $1.7 billion in economic damage for each utility by 2050.

Next, we looked at how much utilities have spent on programs to make their assets more resilient. We estimate it would take $700 million to $1 billion for a typical Southeastern US utility to prepare for impacts related to climate change. That is less than current 20-year storm costs of $1.4 billion and much less than the projected future storm costs of $1.7 billion. While each utility's cost-benefit calculation will differ based on its unique risk exposure profile and infrastructure costs, our conclusion is that it pays to prepare for extreme weather (Exhibit 2). There are also likely to be ancillary benefits, such as improved reliability and enhanced diversity of supply.

This analysis only looks at the threat of increased storm damage to these ten utilities as a potential future cost; the National Climate Assessment notes that utilities could also see negative impacts from increased temperatures and heat waves, as well as sea-level rise even in the absence of storms. This will increase the financial costs to utilities of climate change and increase the benefits of being prepared.

How to improve preparedness and resiliency
Many power utilities in the United States have already started taking steps in this direction. There are different ways for them to adapt, depending on their geographic circumstances and natural endowments. Even so, we find that these efforts are clustered around the following themes:

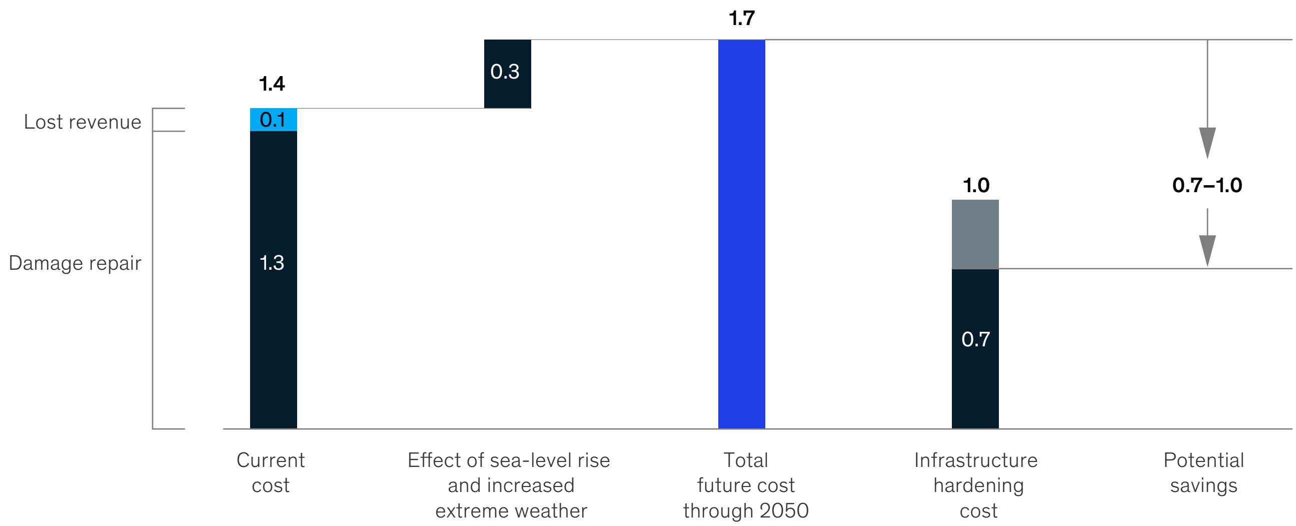
Harden the grid. This term refers to reinforcing the transmission and distribution (T&D) infrastructure to prevent or reduce the damage from extreme weather events. There are many examples. New Orleans Entergy, which lost 95 out of 125 miles of transmission lines during Hurricane Katrina, has invested $1 billion to improve the resilience of the substations and T&D lines, to ensure that they can withstand a storm of similar magnitude.

Similarly, after Superstorm Sandy hit the Northeast in September 2012, ConEd spent $1 billion and four years to strengthen its infrastructure. The utility installed distributed and elevated adjustable relay

Exhibit 2

Taking action on resiliency can be cost-effective, especially when future climate-change risks are taken into account.

20-year storm-damage costs compared with adaptation costs for a Southeastern utility,[1] $ billion



20% Current probability of experiencing storm damage in a given year

23% Projected increase in utility storm damage costs by 2050

[1] Estimated costs for a typical Southeastern utility.
Source: Energy Information Administration; National Climate Assessment; utility financial statements

panels; elevated control houses; ensured all new equipment in flood zones will be able to function if submerged; strengthened overhead lines; and added capabilities to allow isolation of parts of the grid in order to reduce the number of customers affected by damage to one section.

Florida Power & Light (FPL) embarked on a long-term grid-hardening program after Hurricane Wilma caused extensive damage in 2005. FPL spent more than $3 billion on flood protection, distribution feeder reinforcement, and replacing wood poles with steel or concrete structures, among other programs. FPL has also buried power lines underground in select areas, as have other utilities, though the cost-benefit analysis of doing so is mixed.

These investments are relatively recent. Moreover, the timescales are extended and long-term effects are therefore difficult to calculate. It is too early to know, then, whether these efforts will work as intended. What can be said is that in each case, different utilities chose a similar strategy and that their infrastructure is stronger as a result.

Explore nonwire options that go beyond hardening the grid. Grid hardening is expensive, and even an extensive program may not be enough to cope with the most extreme events. After completing much of its $3 billion grid-hardening program, for example, FPL still suffered more than $1 billion in damage during Hurricane Irma in 2017. There are other ways to build resilience and adaptability. Here are some possibilities:

— **Decentralizing generation.** Locating smaller, utility-scale facilities closer to population centers can reduce reliance on long transmission lines that are vulnerable to damage during storms. It also means that if one facility goes down, others still keep going. FPL, for example, is beginning construction on four new solar plants. While economics and FPL's clean-energy strategy played a large role in the decision, one of the installations in Miami–Dade county is explicitly designed as part of a resiliency strategy to provide more local generation.

— **Battery storage.** Batteries can provide backup power in the case of outages caused by storms and help utilities meet spikes in power demand. In 2017, Duke Energy announced a plan to invest $30 million to install North Carolina's largest battery-energy storage system to provide back-up power and improve grid reliability. In 2018, Duke increased the investment to $500 million over 15 years. In addition to providing enhanced reliability to the grid, these investments have already enabled the deferral of the construction of a new gas-peaker plant and allowed the utility to integrate larger amounts of renewable power into its mix.

The world's biggest lithium-ion battery was installed in the state of South Australia in 2017 near the Hornsdale Wind Farm; the $63.25 million project was intended to support its main power grid during peak summer demand and to help integrate renewable energy. In 2018, the first full year of operation, the system brought in $20.7 million in revenues.

— **Microgrids.** A microgrid is a set of locally controlled loads and distributed-generation resources that can function apart from the centralized grid. A microgrid can power a specific site, such as a jail, campus, or office building; utilities can deploy them to provide backup power in the event of power outages on the central grid. Batteries can also provide power to microgrids.

After Hurricane Irene knocked out power to many Connecticut residents in 2011, the state began encouraging the formation of microgrids to improve resiliency. Subsequently, the town of Fairfield launched a microgrid for its critical infrastructure services, including its police department, fire department, communications center, and homeless shelter. While no storm has knocked out power to the main grid since installation, the town estimates the combined heat-and-power microgrid has saved the town an estimated $60,000 a year in electric expenses and $10,000 in heating expenses during normal operations—an example in which improving resiliency can be cost-effective.

— **Environmental management.** Active management of the natural environment can provide utilities and other infrastructure owners with protection against extreme weather. For example, coastal wetlands provide a natural barrier to lessen the impact of extreme storms. A recent study estimated that New Jersey's coastal marshes reduce flood damage by 16 percent during normal storm years, and that after Hurricane Sandy in 2012, the presence of wetlands and marshes up and down the east coast reduced hurricane damage by 27 percent.

  In 2015, Entergy and other Gulf Coast companies began a pilot program to restore coastal wetlands in Louisiana to provide storm protection. The effort can also be counted as an offset to the companies' carbon emissions, since wetlands act as a carbon sink, providing a direct financial benefit.

  The Alabama Power Company has constructed wetlands near its generation facilities; these also serve as filtration systems to remove chemicals from the water used in power-plant cooling.

Factor an up-to-date view of risk into operations. Utilities should consider the increased risk from climate change predicted by the Fourth National Climate Assessment and other reports as they examine their daily operations, not just when they are considering long-term investments. In a 2019 filing before the California Public Utilities Commission, Southern California Edison proposed changes to its operations to reflect its acknowledgement of the increased risk of wildfires. These measures include the increased monitoring of electrical equipment, clearing trees that pose a wildfire risk, and enhancing situation-awareness capabilities to allow for rapid emergency response, as well as prioritization of investments based on which locations are at greatest risk of wildfires.

Look for new partners to help develop and finance resiliency strategies. Utilities can work with insurers and reinsurers to assess climate risk and adaptation strategies. The latter can then help them underwrite those risks after the utilities have made agreed-upon investments in modernizing their infrastructures. In developing the Gulf Coast resiliency report, for example, Entergy worked with Swiss Re to develop regional models for climate risk assessment.

Public–private partnerships are another way to finance new investments in resiliency (see sidebar, "The role of regulation"). One effort in Colorado is creating a demonstration solar panel and battery-storage microgrid outside Denver. In the event of an outage, the microgrid would automatically be switched on, with power provided by an intelligent rooftop photovoltaic battery system to keep critical services running. The project is also intended to improve the integration of renewable energy and to cope with peak demand.

Finally, research institutions can help apply new ideas and strategies to a specific utility's context. For example, the Natural Capital Project—a partnership among Stanford University, the Chinese Academy of Sciences, the University of Minnesota, the Stockholm Resilience Centre, the World Wildlife Fund, and the Nature Conservancy—works with stakeholders to develop plans and stimulate investment in developments that improve resiliency through nature-based projects.

The role of regulation

Climate change could burden utilities with substantial costs above and beyond the damage caused by a particular event. In some jurisdictions, utilities can be held responsible for lost economic output caused by power outages. These assessments are, of course, ultimately borne by consumers, in the form of higher rates. A decade after Hurricane Katrina, Gulf Coast consumers were still paying storm damage charges.

Given their capabilities and knowledge, regulators are well positioned to work with utilities to help them make cost-effective investments in resiliency. Regulators can incentivize utilities to develop climate-adaptation plans that protect and upgrade their infrastructure. They can design liability structures that encourage utilities to take preventive actions by shifting the liability burden if specific measures are taken. And they can encourage experimentation and forward thinking. Regulators will have to define their priorities based on their specific circumstances, such as the state of their grid and generating system.

An example of resiliency-oriented regulation comes from Florida. Since 2006, the Florida Public Service Commission has required investor-owned power utilities to devise three-year storm-protection plans. The commission has also required utilities to implement aggressive vegetation management and an inspection program with an eight-year life cycle for wooden poles. Some utilities, for example, have replaced those poles with concrete structures designed to withstand 140 mile-per-hour winds.

These and other ideas must be stress tested and analyzed to ensure they are appropriate for specific circumstances. But the point is to begin considering them.

Utilities are asset-heavy businesses that must maintain extensive and expensive infrastructures. Unless they become more resilient to extreme weather, those assets will be vulnerable—and so will the utilities. They are not, however, helpless before climactic impacts. They can prepare. Not only does this make good sense, it is good business.

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