

PG&E: MARKET AND POLICY PERSPECTIVES ON THE FIRST CLIMATE CHANGE BANKRUPTCY

**BY JOHN J. MACWILLIAMS, SARAH LA MONACA AND JAMES KOBUS
AUGUST 2019**

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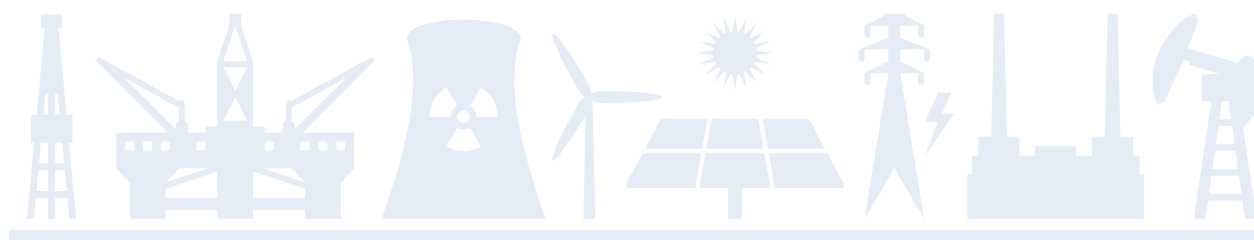
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EXECUTIVE SUMMARY

The Pacific Gas and Electric (PG&E) bankruptcy, which was caused by liabilities resulting from massive wildfires, has widely been called the first climate change bankruptcy. It will likely not be the last, as climate change exacerbates natural disasters, leading to more frequent and intense wildfires, storms, and flooding. Wildfires alone could become up to 900 percent more destructive in certain regions by midcentury, and utility assets will also be increasingly exposed to threats stemming from hurricanes, rising sea levels, and other climate-related events.

These extreme weather events will increase costs to utility-sector stakeholders, including investor-owned utilities, state and local governments, ratepayers, and taxpayers. These risks could place financial stress on utility companies, drive up electricity rates, crowd out essential investment in renewable energy and grid upgrades, and disrupt service.

In this paper, Columbia University's Center on Global Energy Policy reviews and analyzes the PG&E bankruptcy, assesses how capital markets have reacted to the bankruptcy through the lens of valuations in the US utility sector, and discusses policy implications of California's recent legislative response to wildfire risk. This paper examines market indicators to assess investor expectations of climate risk exposure and likely cost allocation. Neither debt nor equity markets suggest widespread concern about climate risk in the utility sector.

In the absence of strong market signals to encourage climate risk mitigation, the authors find that policy frameworks are needed to ensure that companies make necessary preventative investments and to define how costs will be allocated among stakeholders. This paper also reviews a recently passed California bill aimed at achieving these objectives and the lessons and best practices it offers for other policy makers. In short, the paper finds the following:

- Market indicators suggest that the California wildfires and subsequent PG&E bankruptcy have not caused imminent concern about climate risks in the utility sector. Equity valuations for the sector remain strong, with a utility stock index trading at a higher-than-average premium to the market benchmark. In credit markets, regulated utilities in the United States have raised more than \$50 billion of corporate debt in 2019 to date, and borrowing spreads are currently below historical averages.
- There are several reasons why markets may not reflect widespread climate risk to utilities, despite the scientific evidence around likely future damage. Investors may believe that cost increases from climate change will occur too far in the future to materially impact the present value of their investments. Even if investors believe that climate change risks are material to valuation, they may also believe that such risks will not be considered by other investors for some time. Investors may be viewing wildfires as a California-specific risk, though the regional skew of wildfires is likely to shift significantly in coming years. They may lack the information or modeling tools for assessing the likelihood and geographic dispersion of high-impact tail events, such as the wildfires that PG&E faced.



- Financial markets may also reflect the belief that the costs of climate change in the utility sector will fall predominantly on ratepayers, insurance companies, and/or taxpayers rather than investors, and therefore investors may not view themselves as materially exposed.
- California's recent creation of a wildfire insurance fund with contributions from both ratepayers and companies provides important policy lessons for designing comprehensive frameworks to allocate climate damage costs. These include the strengthening of both regulatory and corporate climate resilience expertise, mandating preventative investment as a prerequisite for cost-recovery mechanisms, defining utility financial exposure for climate damage situations, and providing liquidity for utilities to provide essential services when facing large disasters.
- The policy also presents some potential pitfalls that may be instructive for other state policy makers. The legislation sets aside large reserves for future damage, a necessary measure, but one that will result in higher electric bills. The bill does not allow utilities to earn a return on safety-related spending, which broadly diminishes incentives for proactive climate mitigation investment. The potential insufficiency of the wildfire fund also creates uncertainty about future cost allocation. Finally, failing to reform the California legal framework that allows utilities to be held liable for damages they did not cause perpetuates risks for companies and ratepayers.

If the first climate change bankruptcy is indicative of a new reality, it is not that utilities are going to go bankrupt overnight. Rather, climate disasters will increasingly add financial stress to utility-sector stakeholders, as costs accumulate from both acute events and damaging extreme weather impacts. Adapting the regulatory bargain for a climate-exposed future will require lawmakers, regulators, and shareholders to develop new approaches and new incentive structures to ensure an accountable, robust utility sector. Moreover, while climate change is already presenting real financial challenges to utilities, it will not be the only sector to face large climate-driven costs. Other corporate actors can look to the utility experience to better understand how policy makers, investors, and companies will respond to the growing financial threat from climate change.



INTRODUCTION

In January 2019, Pacific Gas and Electric (PG&E), California's largest electric utility, declared bankruptcy, estimating that it could face liabilities surpassing \$30 billion from the 2017 and 2018 Northern California wildfires.¹ The PG&E case has been called the first climate change bankruptcy, and commentators have predicted that it is a harbinger of additional bankruptcies caused by catastrophic impacts of climate change. California's subsequent legislation creating a wildfire insurance fund with contributions from both ratepayers and companies represents an important test case for the way that society will allocate the costs of climate damage.

The terms of providing electricity have been governed since the inception of the industry by what has been called the "regulatory bargain": since electricity is an essential service, and is most affordably delivered through a shared infrastructure, a utility operates as a natural monopoly and in return accepts state regulation of its rates and profits. In this framework, the costs resulting from natural disasters have typically been borne by electricity customers in the form of increased rates and bill charges. In the absence of evidence to the contrary, it has generally been assumed that utilities that incur those costs have managed their networks prudently, so companies and shareholders have typically not been penalized.

As California demonstrates, increasingly frequent and intense climate-driven extreme weather events are beginning to strain this framework by adding high recovery costs to already high electricity rates. Yet as costs stress the customer base, they cannot be shifted entirely to utility companies. Maintaining financial soundness is critical to utilities' ability to deliver electricity and make important investments in resiliency and renewable electricity sources to combat climate change. In the context of these trade-offs, policy makers will be forced to grapple with the question of how to pay for climate damages in a way that protects ratepayers but maintains the financial health and accountability of utilities. This is especially true as climate damage becomes more likely to occur and can and should be mitigated through reasonable preventative investments.

The California proposal provides a first, if imperfect, example of an explicit regulatory road map for allocating climate costs. The subsequent policy frameworks that governments implement will shape how these costs will be allocated in the future among shareholders, ratepayers, and federal and state taxpayers. Though it is specific to wildfires, the legislation passed in California provides important takeaways for other states as they shape their own climate adaptations to the regulatory bargain.



CALIFORNIA FACES HISTORIC WILDFIRES AND THE “FIRST CLIMATE CHANGE BANKRUPTCY”

California has faced more destructive wildfires in recent years, exacerbated by the effects of climate change. The fires have resulted in tragic loss of life and catastrophic destruction of homes and properties. They have also led to the state’s largest utility declaring bankruptcy. If PG&E is indeed the first clear example of a climate change bankruptcy, it is important to understand how the company came to declare bankruptcy after last year’s historic wildfires and what the role of climate change was in shaping PG&E’s financial situation.

PG&E is one of three major investor-owned utilities (IOUs) in California, providing electric and gas services to more than five million customers in Central and Northern California. In recent years, the company has faced challenges from intensifying wildfires, beginning with the 2015 Butte Fire, which burned more than 70,000 acres and caused two deaths. The California Department of Forestry and Fire Protection—Cal Fire—determined that PG&E’s equipment ultimately caused the fire. While settlements are still being resolved, the utility estimates it will incur \$1.1 billion in resulting losses.² In 2017, PG&E’s equipment was found to have sparked 18 of 21 major fires in Northern California.³ The company has estimated \$3.5 billion to be a low estimate for likely damages under those settlements.⁴

PG&E therefore entered the 2018 wildfire season already facing considerable fire-related liabilities. The Camp Fire that devastated Northern California communities last November was the state’s deadliest wildfire on record and the costliest natural disaster of 2018.⁵ The disaster claimed the lives of 86 people and resulted in the destruction of over 150,000 acres, 13,972 residences, 528 commercial structures, and 4,293 other buildings. Together with the 2017 wildfires, the company has recorded charges of approximately \$13.4 billion and estimated that its wildfire related liabilities could exceed \$30 billion, a figure that does not include potential punitive damages, fines and penalties, or damages related to future claims.⁶

Facing this wall of potential liabilities, PG&E announced on January 14, 2019, that it would preemptively file for Chapter 11 bankruptcy protection.

Notably for PG&E, California is one of only two states that have a legal framework, known as inverse condemnation, which holds utility companies strictly liable for wildfire damages if the company’s equipment ignites a wildfire even if the utility’s operations were not unreasonable or negligent. This allows for property damages to be brought against utilities even if they are not shown to be at fault.⁷ Nonetheless, while many commentators have suggested that the inverse condemnation framework significantly contributed to PG&E’s financial distress, it is worth noting that the company could potentially have been liable even in the absence of this legal framework. An investigation by Cal Fire confirmed that the fire began when PG&E-owned power lines malfunctioned and ignited surrounding trees,⁸ and subsequent media reporting has raised serious questions with respect to the appropriateness of the company’s operations.⁹

PG&E’s bankruptcy announcement generated an abundance of media coverage and commentary. Many news articles sounded the alarm on widespread climate risk, quoting



experts who said that the PG&E bankruptcy should be a warning for the corporate world. *Bloomberg News* wondered if “California utility PG&E may be the business world’s biggest climate change casualty yet.”¹⁰ The *Wall Street Journal* warned “PG&E: The First Climate Change Bankruptcy, Probably Not the Last.” Former New York City mayor and current chair of the Task Force on Climate Related Financial Disclosures Michael Bloomberg published an op-ed stating that the PG&E bankruptcy “is a wake-up call on financial risks of climate change.”¹¹

How did climate change contribute to the bankruptcy of a major California utility?

Certainly, numerous factors contribute to the cause and spread of wildfires, and it can be difficult to disentangle the complex dynamics when analyzing any one particular incident. Factors that may have played a role in the large 2017 and 2018 fires include vegetation management practices, trends in urban-wildland development, and safety-culture issues that were specific to PG&E. Regarding this last point, it is worth noting that PG&E had faced significant scrutiny for oversight and safety culture issues well before the 2017 and 2018 wildfires. For example, PG&E has been subject to numerous investigations following the 2010 San Bruno pipeline explosion that killed eight people and leveled an entire neighborhood. The utility company even faced a federal criminal trial in which the utility was found guilty of six felony counts.¹² Moreover, a recent *Wall Street Journal* article reported that the company knew that 49 of the steel towers that carry the electrical line that failed (causing the 2018 Camp Fire) needed to be replaced entirely. Facing operational and capital constraints, the company delayed the required upgrades, ranking them as low-risk projects and directing capital expenditures toward what it considered higher priority projects.¹³ In a recent bankruptcy hearing, however, PG&E disputed these accusations, arguing that the deferred projects would not have addressed the conditions that started the 2018 fire.¹⁴

Even considering these additional contributing factors, it is undeniable that climate change also has had an effect on the severity and likelihood of wildfires. Columbia University researchers have found that climate change has caused an extra 4.2 million hectares—an area approximately the size of Massachusetts and Connecticut combined—of wildfire damage in the Western United States since the 1980s. This is nearly double the number of acres burned than would otherwise be expected.¹⁵ While PG&E’s faulty power lines may have sparked the Camp Fire, scientists believe that conditions caused by climate change made the fire more likely to occur and more damaging. Another recent study led by Park Williams, a hydroclimatologist at Columbia University’s Lamont-Doherty Earth Observatory, finds that average summer temperatures in California have risen more than three degrees Fahrenheit since the late 1800s, with three-quarters of the increase occurring since the early 1970s. From 1972 to 2018, the annual acres burned by wildfires have increased by a factor of five, resulting from a more than 800 percent spike in summer forest fires.¹⁶ Researchers note that warming average temperatures in the state have diminished autumn rains and increased winds, which have led to tinderbox conditions as brush and vegetation become drier and more prone to burning.¹⁷ Dana Nuccitelli of Yale Climate Connections outlines several additional academic studies showing how climate change has worsened wildfire conditions in California over the past several years.¹⁸



The California Policy Response

With the 2019 wildfire season already underway, California lawmakers have moved quickly to implement plans for preventing, mitigating, and allocating the costs of future wildfires.

Last month, California Governor Gavin Newsom signed into law a wildfire insurance package that is the first in the nation to address major utility financial risk resulting from increasing climate risk. The legislation is designed both to mitigate the risk of future wildfires and allocate the costs of any future damages, providing improved clarity to investors as to the maximum amount utility shareholders would be expected to pay. The package lays out a total of \$5 billion of safety investments that utilities would be required to make, on which they would not be permitted to earn a return on equity.¹⁹ These include measures such as more frequent power line inspections and better vegetation management. The bill also establishes a Wildfire Safety Advisory Board, staffed by industry experts, to advise the California Public Utility Commission (CPUC). The advisory board would review utilities' implementation of specific safety requirements, including having an approved fire mitigation plan, establishing a fire safety committee, and tying executive compensation to safety culture. On the basis of the review, the board would make a recommendation to the CPUC as to whether to issue a safety certificate to the utility. These requirements are intended to reduce the likelihood of future catastrophic wildfires. However, the proposal goes beyond risk reduction to address how costs would be shared in the seemingly inevitable event that wildfires happen anyway. It creates a \$21 billion insurance fund, capitalized through ratepayer contributions in the amount of \$10.5 billion, as well as \$10.5 billion in company contributions shared proportionally between California's IOUs. While the utilities had the option to instead access a \$10.5 billion reserve fund to be used as a bridge loan facility, PG&E, Southern California Edison, and San Diego Gas & Electric have all confirmed to the CPUC that they will opt in to the \$21 billion insurance fund.²⁰ The CPUC-issued safety certificate would be a prerequisite for accessing funding through these mechanisms.



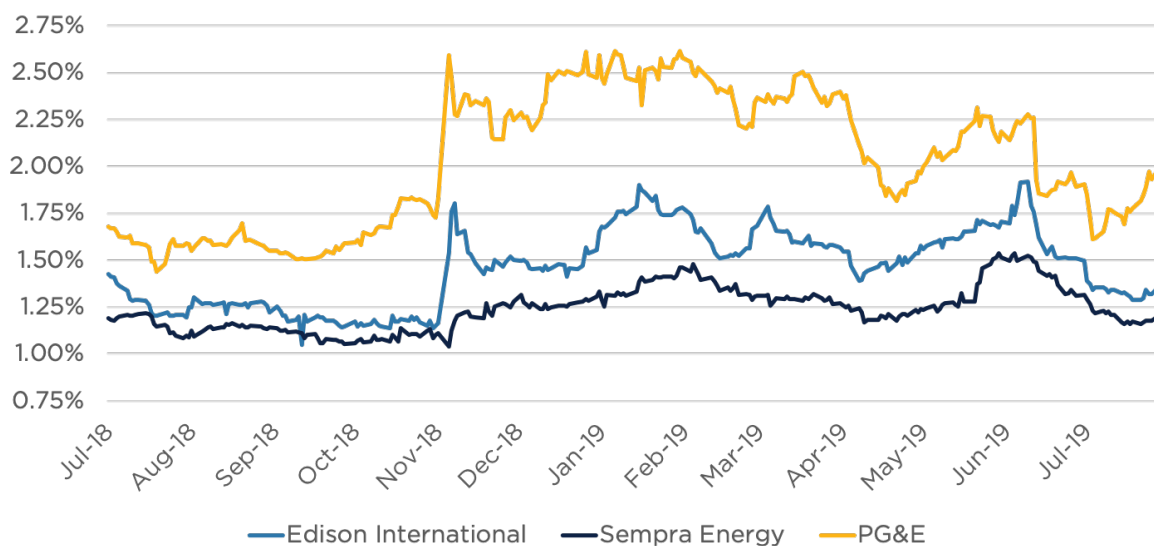
THE MARKET'S RESPONSE

One would expect that a major climate-exacerbated bankruptcy would increase investors' recognition that such events may be more severe and more frequent throughout the industry than previously thought. While in theory this risk has been present for some time, it seems plausible that the severity of the 2017 and 2018 wildfires revealed new information about the seriousness of the risk and brought the issue to the forefront of investor consciousness. It also attracted the attention of the credit rating agencies, with Standard & Poor's (S&P) threatening to downgrade all of the state's utilities to junk status if a new regulatory framework were not adopted.²¹ If investors were of the view that PG&E's was the first of many future climate-driven utility bankruptcies, prospective lenders would begin to demand higher rates on debt, and equity valuations would decline to reflect increased perceived risk. This market response could, itself, present a financial risk to utilities by making capital more expensive or difficult to access. Below, we examine whether the market has behaved in a manner consistent with this expectation.

Are Lenders Treating PG&E as a Canary in the Coal Mine or as an Isolated Event

Looking first at debt markets, there was a marked uptick in debt costs for all three California utilities following the November 2018 wildfires. Figure 1 shows borrowing rates for California IOU parent companies Edison International (which owns Southern California Edison), and Sempra Energy (which owns San Diego Gas & Electric), relative to treasury bonds.²² Interestingly, all of the utilities experienced a sharp spike in borrowing costs in November as details of the Camp Fire came to light, even though the fire was limited to PG&E's service territory. This suggests that the market viewed the 2018 Camp Fire as new information, and investors in the other two utilities updated their beliefs regarding the probability of future wildfires.



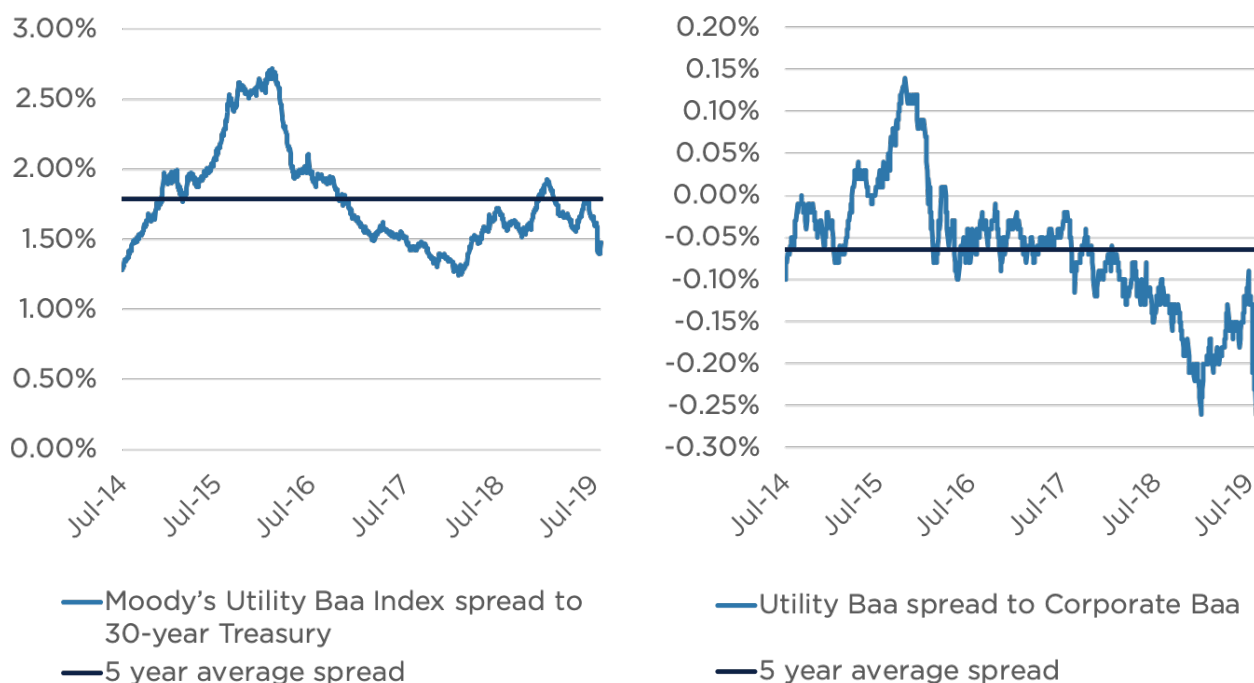
Figure 1: California utilities' borrowing rates (Yield spread over benchmark Treasury bond)

Source: Bloomberg. Data as of 8/6/19. Uses "Mid Spread to Benchmark" function, showing EIX 4 1/8 03/01/48 Corp (parent company of Southern California Edison), SRE 4.15 05/15/48 Corp (parent company of San Diego Gas and Electric), and PCG 3.95 12/01/2047 REGS Corp (PG&E). PG&E debt is unsecured while the other two are secured issuances, explaining some of the outsized PG&E spread.

However, the effect seems isolated to California, and there does not appear to have been a measurable effect across utility credit markets as a whole. Regulated utilities in the United States have raised more than \$50 billion of corporate debt in 2019 thus far, borrowing at an average rate of approximately 3.8 percent. While there was a modest uptick in the average sector spread over treasuries coinciding with the November 2018 Camp Fire, the spread returned to historical levels and is still below its historical five year average of approximately 1.8 percent (figure 2, left image). Looking at utility BAA debt relative to a broad corporate BAA index, the two have tracked each other extremely closely, as one might expect. While there is some selection bias in this analysis as companies are downgraded and removed from the index, utility debt yields are actually trading tighter (i.e., at lower yields) relative to their historical five year average spread (figure 2, right image). These findings suggest that the market is not pricing in outsized risks in the utility sector relative to history.



Figure 2: Utility bond spreads are below historical norms, suggesting the market is not pricing in outsized risks relative to history



Source: Bloomberg. Data as of 8/6/19.

The tenor of debt issuances has averaged over 14 years, with some utilities even issuing debt over more than fifty years. The lack of sustained increase in borrowing costs over those time periods, and comparable duration, indicates that lenders remain comfortable with the financial condition of utilities despite the Camp Fire and subsequent PG&E bankruptcy.²³ This is confirmed by the credit default swap market, which further appears to be pricing in relatively low levels of default risk, even among utility companies operating in California and other climate-exposed regions.²⁴

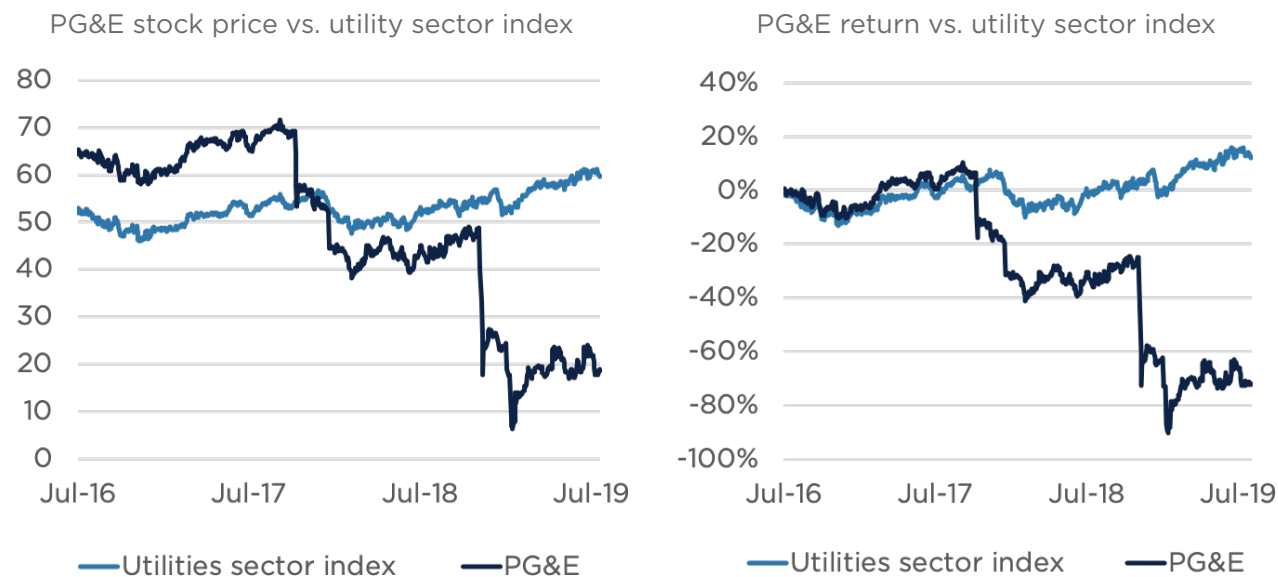
Have the Wildfires or PG&E Bankruptcy Impacted Equity Valuations?

We look first at PG&E's stock price. As shown in figure 3, the company significantly underperformed peer utility companies (as illustrated by the XLU utilities sector index fund) as the severity of the 2017 wildfires became clear. Then, when the devastating Camp Fire hit in November 2018, the stock price experienced a more dramatic fall, culminating in the bankruptcy filing which sent the stock sharply down to approximately \$6.40 per share. Interestingly, however, the stock price has outperformed peer utilities since the bankruptcy filing and has recovered to approximately \$17.00 per share. This means that the market is now reflecting approximately \$9 billion in market capitalization, a large equity value for a company



in the midst of a bankruptcy proceeding. Investors may be concluding that the ultimate liabilities the company is likely to face will be lower than the \$30 billion estimate. Investors may also have lowered their expectations for future liabilities following the passage of the recent California legislation.

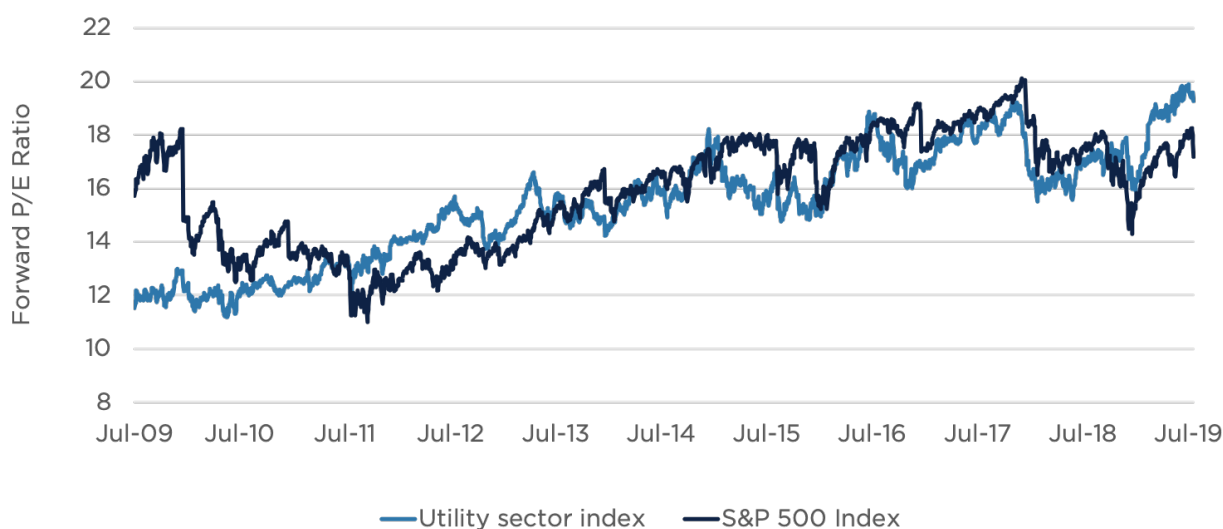
Figure 3: PG&E (ticker: PCG) stock price and returns versus industry average, 2016–2019



Source: Bloomberg - PCG US Equity & XLU US Equity (Utilities Sector SPDR Fund). Data as of 8/6/19.

To examine equity valuations across the utility sector more broadly, we compare the forward price-to-earnings ratio of the utility sector index to the market benchmark S&P 500 index. Figure 4 shows the one-year forward price-to-earnings ratio of the utility sector compared with a market benchmark, and table 1 presents the price-to-earnings premium over the S&P 500 based on forecasted growth. Over the past 10 years, the utility sector has traded at approximately a 3 percent lower price-to-earnings ratio relative to the S&P 500, though in recent months utilities have traded up to approximately a 12 percent premium. While such a univariate analysis may only provide part of the story, given the potential for other factors such as interest rates to impact utility sector valuations, this market reaction does not appear to reflect widespread investor concern that the recent wildfires and subsequent PG&E bankruptcy are an indicator of a new systematic risk across the sector.²⁵



Figure 4: Price-to-earnings ratio of the utility sector index vs. market benchmark, 2009-2019

Source: Bloomberg "BEST PE Ratio" Function for UTY Utility Sector Index and SPX S&P 500 Index. Data as of 8/6/19.

Table 1: Current and future price-to-earnings ratio and earnings growth for utility index vs. market benchmark

Date	2018	2019	2020
S&P 500 Index			
Price-to-earnings ratio	16.48	17.25	15.60
Consensus earnings growth	N/A	8.0%	10.5%
UTY utility index			
Price-to-earnings ratio	16.89	19.33	15.60
Consensus earnings growth	N/A	3.0%	4.7%
Premium (discount) to S&P 500	2.5%	12.1%	18.3%

Source: Bloomberg. Data as of 8/6/19.



Finally, there have been more than \$70 billion of mergers and acquisitions transactions in the US-regulated utility sector over the past few years, with strategic and private equity investors paying high multiples and significant premiums for utility assets, as shown in table 2. While activity has slowed somewhat over the past year in the wake of some notable PUC deal rejections,²⁶ the recent JP Morgan acquisition of El Paso Electric, which operates in a potentially climate-exposed region, reinforces the notion that the market does not appear overly concerned about climate risk in the sector.

Table 2: Mergers and acquisitions activity in the utility sector, 2016-2019

Date	Acquirer	Acquiree	State(s)	Enterprise Value (\$bn)	Premium Paid
6/3/19	JP Morgan Infrastructure Investments Fund	El Paso Electric Co.	TX, NM	4.3	17%
1/2/19	Dominion Energy	Scana Corp	SC	14.6	31%
5/21/18	NextEra Energy	Gulf Power	FL	6.5	N/A
4/23/18	Centerpoint Energy	Vectren Corporation	IN, OH	8.5	28%
8/20/17	Sempra Energy	Oncor/Energy Future Holdings	TX	18.8	N/A
7/19/17	Hydro One	Avista Corp	WA, OR, ID, AK	5.3	24%
5/31/16	Great Plains Energy	Westar Energy	KS	12.2	36%

Source: Company press releases and SEC filings

In summary, these analyses suggest that the capital markets do not view the California wildfires and PG&E's subsequent bankruptcy as indicative of a widespread imminent climate risk for utilities. Though there has been some impact to the financing costs of the other investor-owned utilities in California, the effect has not been borne out in aggregate utility indicators.



NO MARKET PANIC, BUT RISKS REMAIN

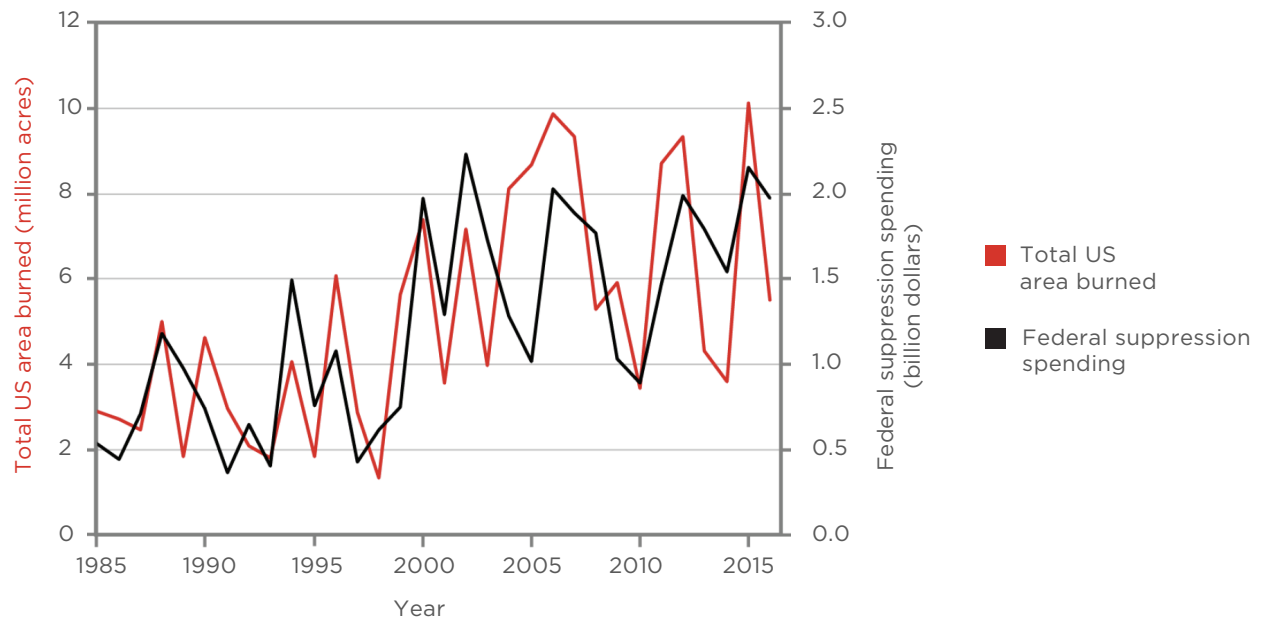
As shown above, despite the dire tone of articles touting PG&E as a harbinger of future climate change bankruptcies, utility investors do not appear to be pricing in material financial climate risk. This is, for the moment, good news for companies and for ratepayers, who would pay for the higher costs of capital. But how does it square with the potential for climate-worsened extreme weather events? Climate change risks in the utility sector are not unique to PG&E or California. Research indicates that climate change will increase the frequency and severity of extreme weather events across the United States.

Wildfires

Wildfires pose a particularly acute threat to utilities. They are forecast to become more severe, more frequent, and more geographically dispersed. They are also extremely costly and represent the singular type of climate change impact that utilities can be shown to directly cause.²⁷

As discussed, climate change induced temperature increases and droughts dry up forests and vegetation, fueling larger, more damaging wildfires. Figure 5 shows US wildfire damage by acres burned from 1985 to 2015. Looking to the future, while there is considerable variability in the magnitude of forecasts, studies consistently project significant increases across the United States. The United States government's Fourth National Climate Assessment, released in November 2018, notes that "by the middle of this century, the annual area burned in the western United States could increase from two to six times from the present, depending on the geographic area, ecosystem, and local climate." The assessment cites increased temperatures, earlier snowmelt, and more intense summer droughts as contributors to increased wildfires.²⁸



Figure 5: Acres burned from wildfires and federal suppression spending, 1985-2015

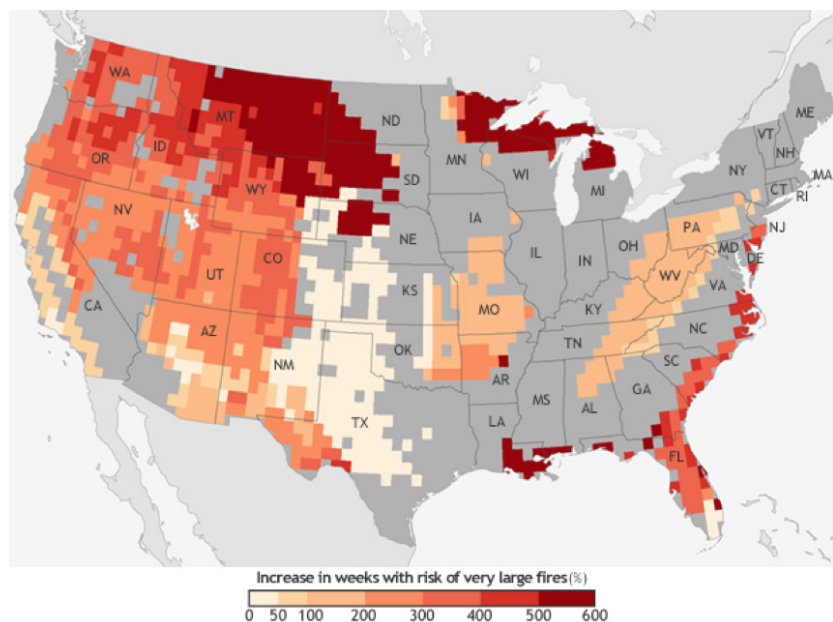
Source: [Fourth National Climate Assessment](#), 2018

A meta study published in the *Journal of Atmospheric Environment* summarizes several peer-reviewed projections for future area burned across the whole country. While some studies reflect only single-digit increases at the low end, others project increases of up to 900 percent in certain regions by midcentury.²⁹ Forecasts could be even more drastic if updated to reflect the unexpectedly severe 2017 and 2018 wildfire seasons.

The greatest destruction from wildfires (by acres burned) is concentrated in western states. However, the National Climate Assessment anticipates increased wildfire activity not just in the west but also in several southeastern states.³⁰ Figure 6 shows the expected percentage increase in large wildfires by state, revealing widespread increases in wildfire risk in both western and some eastern and Midwest areas.³¹



Figure 6: Projected increase in “very large fire weeks” by midcentury (2041-2070) compared to 1971-2000



Source: Barbero, R.; Abatzoglou, J.T.; Larkin, N.K.; Kolden, C.A.; Stocks, B. 2015. Climate change presents increased potential for very large fires in the contiguous United States. *International Journal of Wildland Fire*.

As wildfires become larger and more common, their costs will increase dramatically as well. A 2017 Department of Commerce report, written before the record-setting 2018 fire season, estimated the annual direct costs of wildfires at \$7.6–\$62.8 billion in the United States alone, with the direct and indirect economic losses representing an incremental \$63.5–\$285 billion of damages.³² Applying similar growth rates for forecasted acres burned to these cost estimates, annual direct and indirect wildfire damages could easily surpass \$500 billion. This approach may also be underestimating the potential economic damage due to increased development at the wildland-urban interface. These types of areas, where homes are placed in natural areas, currently constitute 9 percent of the United States total land area but are projected to double by 2030.³³ This has the potential to increase the economic damage per acre burned.

Hurricanes, Flooding, and other Climate Impacts

What makes utilities particularly financially vulnerable to wildfire impacts is that they can be held responsible for actually causing fires, as happened in the case of PG&E. However, other climate-related factors such as hurricanes and flooding also represent material risks to the utility sector (as well as to other sectors of the economy.)

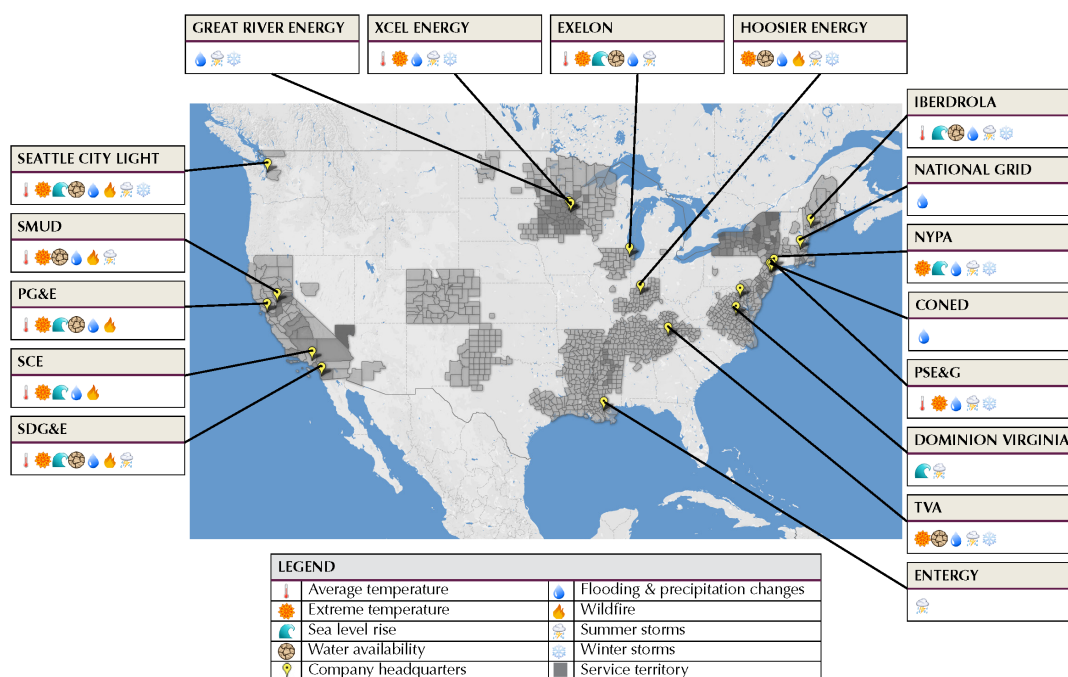
Hurricanes and sea level rise are forecast to increase in both frequency and intensity in the coming years and to affect a larger number of people. Peer-reviewed analysis from the



Congressional Budget Office estimates that the number of people living in hurricane-prone counties in the United States will grow 800 percent by 2075.³⁴ A 2019 paper from asset manager Blackrock Investments details climate risks to the utility sector, noting that storm surge, high winds, and flooding from hurricanes pose a risk to several categories of utility assets, including power plants and transmission and distribution networks.³⁵ The United States Department of Energy estimates that sea level rise causes hurricane storm-surge exposure increases of 12 to 40 percent for power plant assets and 18 to 44 percent for substations.³⁶

A 2016 utility climate risk report from the United States Department of Energy states that “changes in climate and extreme weather, including increasing temperatures, decreasing water availability, more intense storm events, and sea level rise have already damaged or disrupted electricity services.” The report details the climate exposure assessments of several major utility companies across the country.³⁷ Self-assessed climate vulnerabilities are shown in figure 7, with 13 of 17 identifying a risk from increased summer storms, and 15 of 17 concerned about flooding and precipitation. (Notably, many utilities also included wildfire risk in their self-assessments).

Figure 7: Specific climate impacts included in utilities’ vulnerability assessments



Source: [US DOE](#), 2016.

Climate impacts will result in increased costs and financial stress to both ratepayers and utilities.³⁸ Moreover, the damage will not be evenly distributed geographically. As a result, certain utilities are likely to face overwhelming costs while others escape the worst impacts. It can be difficult to predict ex-ante which climate-exposed utilities will bear the brunt of the damage, but these risks should not be discounted.

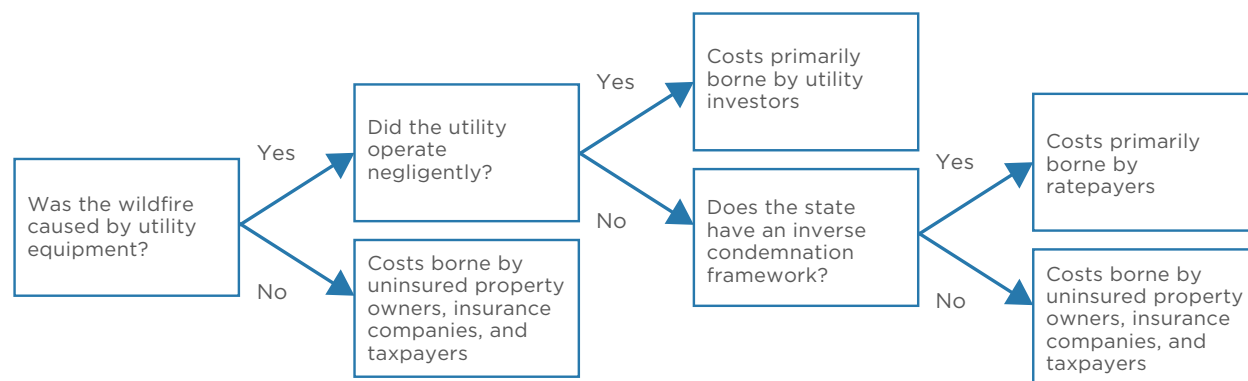


PRICING CLIMATE CHANGE RISK IN THE UTILITY SECTOR

As discussed above, markets do not appear to be reflecting systemic climate change risk in the utility sector outside of California, despite scientific consensus that climate change presents a real and substantial threat to the industry. There are several potential explanations for this market reaction.

First, outside of California, financial markets may reflect the belief that the costs of climate change in the utility sector will fall predominantly on ratepayers, insurance companies, and/or taxpayers rather than investors. Utility sector investors may thus be anticipating increases in climate costs but may not view themselves as materially exposed. Not all fires are caused by utility equipment, and of those that are caused by electricity infrastructure, the liability ultimately depends on several factors. These include whether the utility company is found to have operated prudently, whether an inverse condemnation framework is in place, and whether an effective cost-recovery process is established. Figure 8 below outlines several different wildfire cost-sharing scenarios, showing that investors are likely to be exposed to climate costs only when specific conditions are met. Similar principles regarding prudence and cost recovery are likely to determine investor exposure to non-wildfire climate events such as hurricanes and flooding. If investors assign low probabilities to the cases of negligence and ineffective cost recovery, then it would be reasonable for climate risks to not be materially reflected in utility sector financial assets, even if investors believe that climate change is going to make these events more frequent and damaging over time.

Figure 8: Flowchart illustrating wildfire cost allocation under various scenarios



Source: Columbia University Center on Global Energy Policy

Second, investors may believe that preventative resilience and hardening investments such as those mandated by the recent California legislation may significantly reduce the damage that utility companies will face from climate change.



Third, depending on the particular asset class, investors may believe that cost increases from climate change will occur too far in the future to materially impact the present value of their investments. Credit default swaps, for example, are typically structured over a five year period—a time period over which the increased costs of climate change may not materially impact their value. For equity investments and longer term debt, the costs of climate change may be too far in the future to materially impact present values if high discount rates are used.

Fourth, even if investors believe that climate change risks are material to valuation, they may also believe that such risks will not be considered by other investors or reflected in asset prices for some time, and therefore may discount these risks. This may be particularly true given the fact that the investment time horizons for many public market investment funds can be measured in months, and that long-term value investors may only hold positions for a few years. While the early impacts of climate change are becoming painfully apparent now (as evidenced by the California wildfires), the worst of the damage is not expected until midcentury or later.

Fifth, investors may be viewing wildfires as a California-specific risk. Indeed, California has been disproportionately affected in recent years. In 2018, California saw over 80 percent more acres burned than Nevada, the second most affected state. However, as noted previously, the regional skew of wildfires is likely to shift significantly over time (see figure 8). It is not clear that these forecasts are widely appreciated by investors. Moreover, although inverse condemnation is often held up as a reason why wildfire risk is largely isolated to utilities in California, it is worth noting that utilities in other states may still be held liable if they are found to have operated their system in an imprudent or negligent fashion.

Finally, investors may lack the information or modeling tools for assessing the likelihood and geographic dispersion of high-impact tail events, such as the wildfires that PG&E faced. As with any risk, one needs to consider the underlying distribution of potential outcomes. Scientists are repeatedly warning that climate change is happening faster than previously forecast, and therefore that the world will face catastrophic effects sooner than expected. Investors may view climate risk as difficult to quantify for any specific utility company given the difficulty in predicting which utilities may be impacted by climate disasters. The combination of these factors may be causing investors to discount these risks in their valuations. While utilities (and other sectors) may not be in imminent danger of bankruptcy, the “tail” risk in the climate risk distribution may be considerably greater than is currently being priced by capital markets. As the California situation suggests, the probability of high-consequence events is increasing.

It is likely that each of the explanatory factors identified above are contributing in some measure to investor outlooks on climate risk. This discussion naturally raises important questions about market efficiency and climate change risk in financial markets. Investor appreciation of climate risk is a complex subject, and there is an expanding field of research that examines market pricing of climate change risk. Examples of such research include a 2019 paper led by Columbia University economics professor Harrison Hong, which analyzed publicly traded food equities and concluded that these securities have underreacted to climate change risks such as droughts. A 2018 Society of Actuaries study examined trading



dynamics around the introduction of emissions trading schemes and concluded that “Carbon and climate change risks have not been fully recognized and priced by the stock markets in Europe and North America.” With respect to the real estate market, a 2018 paper found that houses projected to be underwater in climate change “believer” neighborhoods tend to sell at a discount compared to houses in neighborhoods with a high percentage of climate change deniers. A summary of additional literature on pricing of climate risk is available in Appendix A. Most, though not all, of the analyses reviewed have found instances of market inefficiency. Few studies have evaluated efficient pricing of climate risk among utilities. One notable exception is an analysis from Blackrock Sustainable Investing which examines utility equities and points to evidence of price inefficiencies arising from extreme weather events.³⁹ Additional research will be required to assess the full range and weighting of the relevant factors, however, it seems likely that some degree of climate risk mispricing is occurring in the utility sector.



POLICY TAKEAWAYS

It's not obvious that there is widespread climate-driven solvency risk in the utility sector at present. However, climate research indicates quite clearly that these risks will increase. Utilities and the cities and towns that they serve need to begin investing large amounts of capital now to mitigate climate damage, adapt to inevitable adverse climate effects, and avoid even higher costs that will result from delay. California has found itself on the front lines of this issue. As the risks of hurricanes, wildfires, extreme temperatures, and sea level rise become more pronounced and more likely, regulators throughout the United States will need to grapple with the same issues confronting California. Policy makers will need to create more comprehensive frameworks to allocate risks and costs among the various stakeholders. California's recent legislation provides a framework that other states can build upon. The bill aims to implement several constructive key principles:

1. *Strengthening Regulatory and Corporate Climate Resilience Expertise and Climate Planning Requirements*

The California framework sets an example for cultivating deep climate risk expertise among regulators and government agencies. The recent legislation establishes a safety advisory board, situated within the California Public Utility Commission, which will review utilities' comprehensive wildfire mitigation plans every three years. To our knowledge, this is the first such wildfire safety board established by a public utility commission. States prone to storms and hurricanes have implemented infrastructure hardening and storm resiliency planning requirements (e.g., recent legislation in Florida and an ongoing Hurricane Sandy response in New York). But California's plan goes further by specifying required mitigation measures and establishing a dedicated commission of experts to review safety plans. Other climate-vulnerable states could benefit from adapting aspects of this approach to safety planning, particularly those prone to wildfires that could learn from sharing of best practices on fire mitigation. California—and others—should ensure the effectiveness of safety review boards by providing adequate compensation to attract the necessary level of expertise.

An important caveat to the merits of the wildfire mitigation planning efforts is that part of the approach to risk reduction includes exercise of public safety power shut-off actions, known as deenergization policy. According to the CPUC, deenergization may be used as “a preventative measure of last resort if the utility reasonably believes that there is an imminent and significant risk that strong winds may topple power lines or cause major vegetation-related issues leading to increased risk of fire.”⁴⁰ The extent to which PG&E and the other California IOUs will need to rely on shutting off power to customers is not clear. Neither is it apparent how vulnerable customers, such as the young, elderly, and those with electrical medical equipment, will be considered in a deenergization event. Using all available technical and regulatory tools to prevent wildfires is critical, but it should be noted that frequent disruptions could threaten the fundamental principle of the regulatory bargain that utilities provide acceptable,



reliable service. Indeed, this may be one way in which climate change contributes to the utility “death spiral.” In the deenergization case, frequent outages may degrade the utility’s quality of service, resulting in load defection from customers who can procure alternatives in the form of distributed resources (e.g., rooftop solar and home battery systems). Remaining customers (who are typically more financially constrained) are left paying higher rates, which encourages further defections

2. *Mandating Preventative Investment for Access to Cost-Recovery Mechanisms*

A clear strength of the California legislation is that preventative measures are a prerequisite to access the wildfire insurance fund. The bill requires that utilities maintain a current safety certification based upon the wildfire advisory board’s review of multiannual wildfire safety plans. In the event of a wildfire affecting a particular IOU, the onus will be on the utility to demonstrate that it acted reasonably in order to access the state’s insurance fund. However, any utility holding a safety certification will be considered to have acted reasonably unless another party can raise “serious doubt” about the company’s prudence—a baseline for prudent management outlined by the Federal Energy Regulatory Commission.⁴¹ While the ability for parties to raise doubts places some burden on utilities to defend their conduct, the introduction of this standard is seen by many as providing more protection for utilities than was previously the case.

Some regulators have already implemented requirements mandating preventative investments. In June 2019, for example, Florida governor Ron DeSantis signed a law requiring the state’s utilities to submit storm protection plans covering a 10-year planning period. Storm protection plans approved by the public utility commission may then be funded by a dedicated on-bill charge, separate from base rates. Unlike California’s proposed legislation, the new Florida law allows utilities to earn a return on equity invested in approved storm planning activities.⁴² New York state has also implemented storm recovery requirements under which the Public Services Commission (PSC) can fine utilities for failure to maintain service following a storm.⁴³ However, while the program is a progressive step toward performance-based utility regulation, it is not directly aimed at reducing the costs of climate-driven damage to utility infrastructure. Establishing a link between preventative measures and cost recovery, as the California bill does, is a sensible requirement that appropriately incentivizes utilities to take necessary steps to avoid or mitigate damages. The requirement should be good news for both shareholders and ratepayers, as preventative investments in the near term should prevent considerably higher expense from future fires.

3. *Defining Utility Financial Exposure to Reduce Investor Uncertainty*

The investment community had expressed significant concern with the original California framework, given the potential for the state’s investor-owned utilities to face uncapped wildfire liabilities, even when found to have operated prudently. While this risk had been present for quite some time, the severity of the 2017 and 2018 wildfires underscored the large magnitude of the risk and brought the issue to the forefront of investor consciousness. It also attracted the attention of the credit rating agencies, with S&P threatening to downgrade all of the state’s utilities to junk status if a new



regulatory framework were not adopted.⁴⁴

The new legislation does not eliminate risk to shareholders, but it does more clearly define the magnitude of utilities' financial exposure to wildfires via the following framework:

- If a utility is found to have acted prudently, it can pay out wildfire damage claims using money from the \$21 billion wildfire fund and is not required to replenish the fund.
- If a utility is found to have acted imprudently, it may still use money from the fund to pay out wildfire claims, however it must then replenish the fund up to a cap calculated as 20 percent of that utility's equity transmission and distribution rate base. This amount will vary for each of the IOUs, but PG&E's cap equates to approximately \$2.4 billion.⁴⁵
- If a utility is found to have operated in a "conscious or willful disregard of the rights and safety of others," then there is no cap on the amount it may be required to reimburse the fund.
- If a utility is "the subject of an insolvency proceeding," the company may only use the fund to pay 40 percent of its claims.

Relative to the previous regulatory framework, this provision is beneficial for investors and will help ensure that utilities have access to low-cost capital needed to make resiliency and renewables investments at reasonable terms.

It should be noted that paragraph 2, above, which caps investor liability even in cases of imprudence, is not without controversy. This limited liability framework represents a risk transfer from investors to ratepayers and in isolation would lessen the utilities' incentive to make meaningful investments to reduce wildfire risk. There are, however, other aspects of the California legislation that incentivize utilities to proactively address wildfire risk, so it does not seem like the financial liability cap is likely to create a moral hazard.⁴⁶

4. *Providing Liquidity and Enabling Utilities to Provide Essential Services When Facing Large Disasters*

Although it is vitally important to create accountability for mismanagement and inattention to the serious risks created by wildfires and other climate-related incidents, bankrupting the nation's utilities is in no one's best interest. Higher financing costs lead to higher electric bills paid by ratepayers, threaten recovery for victims, reduce states' abilities to make resiliency and renewable investments, and create uncertainty for employees and contractors.⁴⁷ Unlike existing reserve funds set aside for disaster cost recovery, the scale of funding in the California legislation is intended to ensure liquidity in the case of large potential liabilities. If indeed climate change promises to bring larger, more frequent extreme weather disasters, then planning to keep utilities financially stable through such events seems prudent (where companies have acted reasonably). While some regulators have established performance-based requirements for utilities to minimize downtime after storms, these requirements relate to immediate



operational performance. Securing reliable service in the longer term will be helped, in part, by keeping utilities solvent during periods of crisis.

Although largely a positive step forward, the California legislation falls short in certain respects, and these potential weaknesses may also be informative to policy makers and regulators in other states.

5. *Setting Aside Large Reserves for Future Damages Will Result in Higher Electricity Rates*

The creation of the wildfire fund requires ratepayers to contribute \$10.5 billion. These funds will be raised by an extension of a “Department of Water Resources” charge that customers in California are already paying. While this will not cause rates to rise in absolute terms, this charge was originally set to expire in 2021, so AB 1054 will lead to higher rates than would otherwise have been in place. As University of California, Berkeley economist Meredith Fowlie points out, California’s retail rates are already high and have been rising faster than inflation since 2013.⁴⁸ However, it is difficult to know what the ratepayer impact would have been without the new legislative framework. Absent a comprehensive policy response to the wildfire risk, California IOUs would likely have faced credit rating downgrades, increasing their cost of capital. This higher cost of capital would then have been passed on to ratepayers. The Utility Reform Network (TURN), a large California consumer advocacy group, did ultimately express support for the bill, although its support appeared tepid, with the organization stating that it “made a political calculation that AB 1054 was the best alternative on the table.”⁴⁹

Across the country, natural disasters worsened by climate change will increasingly be the norm. In addition to retrospective cost recovery, investment in preventative measures requires that electricity rates increase in the short term to prevent higher damages in the long term.⁵⁰ In jurisdictions where such preventative investments have been approved, consumer groups have often opposed resulting rate hikes.⁵¹ The political and social effects of raising customer rates now to mitigate future costs will continue to be a defining tension in the development of regulatory policy to address utility climate risk. Proactive planning before climate damages occur can allow regulators to carefully develop frameworks that minimize rate increases rather than making reactive policy in a politically charged environment.

6. *Disallowing a Return on Safety-Related Spending Does Not Incentivize Investment*

California policy makers were faced with a difficult set of political and economic trade-offs as they attempted to allocate the risks and costs of unprecedented wildfires exacerbated by climate change. And they deserve credit for moving proactively to address this situation. However, if the legislation’s goal is to lower the risk of future disasters, it is unfortunate that the bill explicitly prohibits a return on equity for the first \$5 billion of safety-related investments executed by the state’s utilities. While California utilities have additional incentives to pursue climate damage prevention, regulators in other states could more effectively incentivize timely investment in resiliency, hardening, and safety-related projects by providing a financial benefit. Investor-owned utilities have a duty to their shareholders in addition to their duty to serve and ultimately will



allocate capital with this in mind. Rather than eliminating a reasonable return on these desirable investments, the state could have authorized an attractive return in order to incentivize the utility companies to prioritize their capital investments toward these types of projects and to even aggressively invest beyond the \$5 billion target. The FERC has in the past used ROE “adders” to incentivize investment in certain high-priority transmission projects; a similar approach could be warranted here. Alternatively, the commission could consider implementing a fast-tracked “rider” recovery mechanism that allows the utilities to earn an accelerated and de-risked cash return on designated safety or resiliency investments. If the government wants to penalize the utilities for wildfire mismanagement, there are better options available that don’t distort the incentive for utilities to make much-needed safety and resiliency investments.

7. *Potential Insufficiency of Funds Creates Uncertainty about Future Cost Allocation*

Hopefully, the robust wildfire mitigation measures enacted in the recent legislation will reduce the frequency and severity of the state’s wildfires relative to recent history. However, there is a mix of opinion within the financial community as to whether the \$21 billion fund may prove adequate if current trends persist. PG&E has estimated that its exposure to the 2018 Camp Fire and the 2017 Northern California fires could be in excess of \$30 billion—a figure that does not include potential punitive damages, fines, and penalties or damages related to future claims.⁵² Moreover, this figure excludes a variety of fires that occurred over the past two years in other parts of California outside of PG&E’s service territory. Utilities do carry large amounts of insurance coverage (e.g., PG&E held \$1.4 billion in insurance for wildfires),⁵³ and as noted, they must shoulder costs equaling 20 percent of their equity transmission and distribution rate base before accessing the fund in cases of imprudence. It is also possible that the fund may seek some amount of reinsurance to increase the effective size of the fund. However, even if these factors increase the effective size of the fund to greater than \$30 billion, it is possible that the fund could be exhausted relatively quickly in the event of severe fires. Should the wildfire fund be depleted, it is unclear how future contributions would be handled, but both shareholders and ratepayers can expect to feel more economic pain.

8. *Failing to Reform Inverse Condemnation Perpetuates Risks for Companies and Ratepayers*

While PG&E may have been held liable for the 2018 Camp Fire even without inverse condemnation, this uncommon legal principle is not constructive. The governor’s strike force initially listed “Changing Strict Liability to a Fault-Based Standard” as a potential option in its April 2019 report; unfortunately this was not enacted in the final legislation. Holding a utility responsible for massive property damages when the company is determined to have operated prudently and in good faith results in several unintended consequences:

- It creates liquidity and other financial difficulties for IOUs even if they are ultimately allowed to recover the costs. This is because cost recovery often takes years and creates considerable uncertainty that is reflected in their share prices and borrowing costs.



- It leads to higher utility rates than would otherwise have been in place by shifting the burden of wildfire liabilities to utility companies even when they are found to have operated prudently. Since customer rate levels often act as an indirect “governor” on utility capital investment, inverse condemnation crowds out other essential grid modernization and renewables investments.
- It causes a significant risk transfer from insurance companies and uninsured property owners onto utilities and ratepayers. This implicit subsidy has the unintended consequence of encouraging even greater development along the wildland-urban interface, further exacerbating the wildfire problem.



CONCLUSION

If the first climate change bankruptcy is indicative of a new reality, it is not that utilities are going to go bankrupt overnight. Rather, climate disasters will increasingly add financial stress to all utility-sector stakeholders as costs accumulate from both acute events and damaging extreme weather impacts.

In most cases, when competitive markets identify a risk, they allocate that risk to companies in the form of increased capital costs or even withholding of capital where risks are extreme or existential. In a climate context, higher capital costs provide a market-based incentive for a company to mitigate its climate exposure. Some companies can even shift their business model or exit the market entirely.

It may be desirable for companies in other carbon-intensive sectors to face higher capital costs and to consider altering their business models. In the utility sector, however, it is not clear this would be beneficial. If this were to occur, it could disrupt electricity delivery, raise customer rates, and prevent utilities from making critical grid modernization and renewables investments. Neither is it appropriate for utilities and their shareholders to be immune from costs incurred due to underinvestment in climate mitigation. It is this balance between accountability and preservation of financial stability that is specific to managing climate risk in an industry that provides a public good on a commercial basis.

Permanently higher electricity bills may be an inevitable consequence of climate change. As the California wildfire situation demonstrates, the cost of climate damages is already stretching electricity customers; future demands may be overwhelming. Large-scale investment in preventative measures is required now to avoid even more dramatic damage later. One estimate puts the current investment shortfall in climate risk in the utility sector at \$107 billion by 2020.⁵⁴

Overall, the current cost-recovery system is not designed to encourage investment on the scale that is required to comprehensively address climate risk. California's recent legislation, which allocates these costs among different stakeholder groups, is a first test case of how society will apportion the costs of climate change. Adapting the regulatory bargain for a climate-exposed future will require lawmakers, regulators, and shareholders to develop new approaches and new incentive structures to ensure an accountable, robust utility sector. Moreover, while climate change is already presenting real financial challenges to utilities, it will not be the only sector to face large climate-driven costs. Other corporate actors can look to the utility experience to better understand how policy makers, investors, and companies will respond to the growing financial threat from climate change.



APPENDIX

Publication	Study	Author(s)	Date Pub.	Type of Study	Abstract
SSRN	<i>Do Investors Care about Carbon Risk?</i>	Patrick Bolton, Marcin T. Kacperczyk	7/2019	Academic	This paper explores whether carbon emissions affect the cross-section of U.S. stock returns. We find that stocks of firms with higher CO2 emission intensity earn higher returns, after controlling for size, book-to-market, momentum, and other factors that predict returns. We cannot explain this carbon premium through differences in unexpected profitability or other known risk factors. There is a striking and robust difference in the carbon premia for direct (scope 1 & 2) emissions and indirect (scope 3) emissions. While the former can be explained by industry factors, the latter cannot. We also find that institutional investors implement exclusionary screening based on scope 1 & 2 but not scope 3 emissions. These results are consistent with an explanation based on local thinking or sparse modeling of carbon emissions. Although investors do appear to be aware of risks associated with carbon emissions, they do not precisely map the source of these risks across industries and firms.
Financial Analysts Journal	<i>Hedging Climate Risk</i>	Mats Andersson, Patrick Bolton, Frédéric Samama	9/2014	Academic	We present a simple dynamic investment strategy that allows long-term passive investors to hedge climate risk without sacrificing financial returns. We illustrate how the tracking error can be virtually eliminated even for a low-carbon index with 50% less carbon footprint than its benchmark. By investing in such a decarbonized index, investors in effect are holding a “free option on carbon.” As long as climate change mitigation actions are pending, the low-carbon index obtains the same return as the benchmark index; but once carbon dioxide emissions are priced, or expected to be priced, the low-carbon index should start to outperform the benchmark.
Journal of Econometrics	<i>Climate Risks and Market Efficiency</i>	Harrison Hong, Frank Weika Li, Jiangmin Xu	5/2016	Academic	Climate science finds that the trend towards higher global temperatures exacerbates the risks of droughts. We investigate whether the prices of food stocks efficiently discount these risks. Using data from thirty-one countries with publicly-traded food companies, we rank these countries each year based on their long-term trends toward droughts using the Palmer Drought Severity Index. A poor trend ranking for a country forecasts relatively poor profit growth for food companies in that country. It also forecasts relatively poor food stock returns in that country. This return predictability is consistent with food stock prices underreacting to climate change risks



SSRN	<i>Hedging Climate Change News</i>	Robert Engle, Stefano Giglio, Heebum Lee, Bryan Kelly, Johannes Stroebe	5/2019	Academic	We propose and implement a procedure to dynamically hedge climate change risk. We extract innovations from climate news series that we construct through textual analysis of newspapers. We then use a mimicking portfolio approach to build climate change hedge portfolios. We discipline the exercise by using third-party ESG scores of firms to model their climate risk exposures. We show that this approach yields parsimonious and industry-balanced portfolios that perform well in hedging innovations in climate news both in sample and out of sample. We discuss multiple directions for future research on financial approaches to managing climate risk.
Journal of Business Finance & Accounting	<i>Climate Change and Asset Prices: Are Corporate Carbon Disclosure and Performance Priced Appropriately?</i>	Andrea Liesen, Frank Figge, Andreas Hoepner, Dennis M. Patten	8/2016	Academic	This paper empirically assesses the relevance of information on corporate climate change disclosure and performance to asset prices, and discusses whether this information is priced appropriately. Findings indicate that corporate disclosures of quantitative greenhouse gas (GHG) emissions and, to a lesser extent, carbon performance are value relevant. We use hand-collected information on quantitative GHG emissions for 433 European companies and build portfolios based on GHG disclosure and performance. We regress portfolios on a standard four factor model extended for industry effects over the years 2005 to 2009. Results show that investors achieved abnormal risk-adjusted returns of up to 13.05% annually by exploiting inefficiently priced positive effects of (complete) GHG emissions disclosure and good corporate climate change performance in terms of GHG efficiency. Results imply that, firstly, information costs involved in carbon disclosure and management do not present a burden on corporate financial resources. Secondly, investors should not neglect carbon disclosure and performance when making investment decisions. Thirdly, during the period analysed, financial markets were inefficient in pricing publicly available information on carbon disclosure and performance. Mandatory and standardised information on carbon performance would consequently not only increase market efficiency but result in better allocation of capital within the real economy.
Journal of Financial Economics	<i>An Inconvenient Cost: The Effects of Climate Change on Municipal Bonds</i>	Marcus Painter	5/2018	Academic	Counties more likely to be affected by climate change pay more in underwriting fees and initial yields to issue long-term municipal bonds compared to counties unlikely to be affected by climate change. This difference disappears when comparing short-term municipal bonds, implying the market prices climate change risks for long-term securities only. Higher issuance costs for climate risk counties are driven by bonds with lower credit ratings. Investor attention is a driving factor, as the difference in issuance costs on bonds issued by climate and non-climate affected counties increases after the release of the 2006 Stern Review on climate change.



Business & Society Journal	<i>Climate Change and Financial Market Efficiency</i>	Andrea Liesen	11/2014	Academic	The dissertation examines the informational efficiency of financial markets to price the systematic risk stemming from climate change for European companies. The abstract provides an overview of the underlying theory, introduces the development of hypotheses, the method applied, and data gathered, as well as selected implications of results. The reflection commentary discusses the author's views of the research process as a junior scholar.
Swiss Finance Institute	<i>The Importance of Climate Risks for Institutional Investors</i>	Philipp Krueger, Zacharias Sautner, Laura T. Starks	12/2018	Academic	According to our survey regarding climate-risk perceptions, institutional investors believe these risks have financial implications for their portfolio firms and that the risks have already begun to materialize, particularly regulatory risks. Many of the investors, especially the long-term, larger and ESG-oriented investors, consider risk management and engagement, rather than divestment, to be the better approach for addressing climate risks. Although the investors believe that some equity valuations do not fully reflect climate risks, their perceived overvaluations are not large. In addition, a widespread view exists that climate-risk disclosure needs improvement.
Review of Financial Studies	<i>Does Climate Change Affect Real Estate Prices? Only If You Believe in it</i>	Markus Baldauf, Lorenzo Garlappi, Constantine Yannelis	11/2018	Academic	Scientists agree that climate change will have a significant impact on U.S. coastal regions, yet beliefs among the general population on its occurrence and effects are divided. In this paper we study, both theoretically and empirically, whether real estate valuations reflect these differences in beliefs. We develop a model of housing choice in which agents derive utility from ownership in a neighborhood of similar agents. In equilibrium, agents endogenously sort by belief into geographically distinct neighborhoods. In our empirical analysis, we construct a comprehensive dataset on home transaction prices in the U.S. that maps individual homes to future inundation projections and survey data on beliefs of U.S. population about climate change. Our analysis shows that houses projected to be underwater in "believer" neighborhoods tend to sell at a discount compared to houses in "denier" neighborhoods. This result is robust to a host of empirical specifications that account for variation in climate change awareness over time, salience of flood risk, and house supply effects. Our results suggest that heterogeneity in beliefs about long-run climate change risks are reflected in U.S. real estate market prices.



Review of Financial Studies	<i>Do Fund Managers Misestimate Climatic Disaster Risk?</i>	Shashwat Alok, Nitin Kumar, Russ Wermers	7/2019	Academic	We examine whether professional money managers overreact to large climatic disasters. We find that managers within a major disaster region underweight disaster-zone stocks to a much greater degree than distant managers, and that this aversion to disaster-zone stocks is related to a salience bias that decreases over time and distance from the disaster – rather than to superior information possessed by close managers. This overreaction can be costly to fund investors for some especially salient disasters – hurricanes and tornadoes: a long-short strategy that exploits the overreaction generates a significant DGTW-adjusted return over the following two years.
BlackRock Sustainable Investing	<i>Climate Risk in the US Electric Utility Sector: A case study</i>	Andre Bertolotti, Debarshi Basu, Kenza Akallal and Brian Deese	3/2019	Industry	By measuring climate related risks through the study of physical risks posed by extreme weather, we test our hypothesis that these risks are already embedded into security prices. Through event studies of the US Utility sector, we find that prices anomalies in the range of 1.5% and option volatility shocks of 6% exist in connection with hurricanes while for wildfires, prices change by 1% and option volatilities surge by about 4% in the 30-day period following an event. We propose that efficient markets would not exhibit such a behavior because investors would quickly incorporate climate risks into security prices. Yet, we repeatedly find that price inefficiencies persist around extreme weather events, suggesting that investors continue to overlook this type of risk.
BlackRock Investment Institute	<i>Getting Physical: Assessing Climate Risks</i>	Ashley Schulten, Andre Bertolotti, Peter Hayes, Amit Madaan	4/2019	Industry	BlackRock's collaboration with Rhodium Group combines our asset-level expertise with the latest climate science and big-data capabilities. The result — generating some 160 terabytes of data — is a granular picture of investment-relevant physical climate risks. We can now assess direct physical risks to assets on a local level — today and under different future climate scenarios. We can also estimate knock-on effects, such as the impact on energy demand, labor productivity and economic activity. These tools give us unique insight into the severity, dispersion and trajectory of climate-related risks. This helps us assess whether the risks are adequately priced by markets. Our early findings suggest investors must rethink their assessment of vulnerabilities. Weather events such as hurricanes and wildfires are underpriced in financial assets, including U.S. utility equities. A rising share of municipal bond issuance is set to come from regions facing climate-related economic losses. And many high-risk commercial properties are outside official flood zones.



Mercer Corporate Report	<i>Investing in a Time of Climate Change - The Sequel</i>	Mercer	4/2019	Industry	The Sequel is intended to help investors understand how climate change can influence their investment performance in both the short and long term and what steps they should take to protect and position portfolio assets. Given climate related physical damages under higher-warming scenarios, we encourage investors to adopt a “Future Maker” approach, a term coined in the 2015 Report. Advocating for and creating the investment conditions that support a “well-below 2-C scenario” outcome through investment decisions and engagement activities is most likely to provide the economic and investment environment necessary to pay pensions, endowment grants and insurance claims over the timeframes required by beneficiaries.
Mercer Corporate Report	<i>Trillion Dollar Transformation - Climate Change Investment Risk Management for US Public Defined Benefit Plan Trustee</i>	Mercer / Center for International Environmental Law	10/2016	Industry	The purpose of this paper is to provide an overview of climate change investment risks and opportunities for US public pension trustees, and introduce both quantitative and governance frameworks that trustees can use to approach climate change as an investment risk (as opposed to a nebulous uncertainty) and inform related tangible actions. This paper is a companion piece to the Center for International Environmental Law’s concurrently released report Trillion Dollar Transformation: Fiduciary Duty, Divestment, and Fossil Fuels in an Era of Climate Risk.
The Institutional Investors Group on Climate Change (IIGCC)	<i>Navigating Climate Scenario Analysis</i>	Vicki Bakhsh et al.	11/2018	Industry	This guide aims to serve as a ‘how-to guide’ for institutional investors (asset owners and asset managers), who are beginning to construct and conduct scenario analysis. Building on previous work, including recent reports from the IIGCC4 and UN Principles for Responsible Investment (PRI)5, our aim is to go deeper into the options available for investors looking to undertake this type of analysis, with a focus on how to make it relevant to investment and ownership decisions. Ultimately, we believe scenario analysis can support a culture change within the investment community – where investment decision-makers at all levels take into account the profound systemic and broader macroeconomic effects of climate change as a normal part of their strategic thinking and investment analysis.
BlackRock Investment Institute	<i>Adapting Portfolios to Climate Change</i>	Philipp Hildebrand et al.	9/2016	Industry	Investors can no longer ignore climate change. Some may question the science, but all are faced with a swelling tide of climate-related regulations and technological disruption. We show how to mitigate climate risks, exploit opportunities or have a positive impact.



UBS Asset Management	<i>A Climate primer - an investor's introduction to climate change</i>	Michael Baldinger, Francis Condon	12/2018	Industry	Climate change is one of the most pressing concerns which investors currently face. And for investee companies, climate transition is a material consideration. Nonetheless, there are means by which investors, even those who are new to investing for climate change, can approach the topic and strategies already exist which allow them to manage their exposure to climate change within their chosen risk return profile. Finally, both asset managers and asset owners have the capability to drive positive long-term change by engaging with companies to influence their business models and activities as they impact on climate transition.
University of Cambridge - Institute for Sustainability Leadership	<i>Unhedgeable risk: How climate change sentiment impacts investment</i>	Dr Andrew Coburn et al.	11/2015	Interdisciplinary	Short-term shifts in market sentiment induced by awareness of future, as yet unrealised, climate risks could lead to economic shocks, causing substantial losses in financial portfolio value within timescales that are relevant to all investors. This research shows that changing asset allocations among various asset classes and regions, combined with investing in sectors exhibiting low climate risk, can offset only half of the negative impacts on financial portfolios brought about by climate change. Climate change thus entails “unhedgeable risk” for investment portfolios.
Society of Actuaries	<i>Managing Climate and Carbon Risk in Investment Portfolios</i>	Ken Seng Tan, Tony S. Wirjanto, Mingyu Fang	2/2018	Interdisciplinary	This research focuses on analyzing and managing climate change and carbon risk in the equity investment portfolios of insurance company and pension fund assets. The following findings and contributions are elaborated in this final report: There is a general lack of attention devoted to climate change and carbon risk from an investment perspective, and existing methods for managing the risk are heavily based on divestment from emission-heavy industries and investment in green instruments; Carbon and climate change risks have not been fully recognized and priced by the stock markets in Europe and North America; Drawing from findings from this research as well as established methods in existing studies, we propose a framework for constructing an optimal portfolio with effectively mitigated climate change and carbon risk.



NOTES

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23. A detailed econometric examination of this data could more accurately parse the many factors that shape investors’ lending terms. Nonetheless, the data does not show a shock associated with the California wildfires or PG&E’s bankruptcy.
24. Using Bloomberg’s default CDSW valuation assumptions, five-year CDS prices imply default probabilities of just 4–8 percent for a randomly selected group of 10 regulated utility companies.
25. While beyond the scope of this paper, this premium may also reflect other factors such as



investors shifting portfolio allocations toward more recession-defensive sectors, including utility shares.

26. E.g., the Washington PUC rejection of the Hydro One–Avista acquisition and the initial Kansas Corporation Commission rejection of the Great Plains–Westar transaction.
27. Causing a climate event, in this case, refers to utility equipment actually sparking wildfires, which is not possible in the context of hurricanes or flooding, for example. A more expansive definition of climate damage culpability could arise in the future, as is evident in legal proceedings against fossil fuel energy companies (including utilities). For additional information, see Jennifer Hijazi, “Climate Liability Is on the Rise. Here’s What It Looks Like,” E&E News, August 5, 2019, <https://www.eenews.net/climatewire/2019/08/05/stories/1060850731>.
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