Fire, Wind, and Waves: Grid Resilience Threats and Opportunities in California and New York

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Introduction & Executive Summary

Electrical grids across the United States face a complex and overlapping series of threats. Aging grid infrastructure, coupled with under-investment in maintenance and repairs, has created a precarious situation for many electrical systems. Patterns of human development and forest management have contributed to underlying threats to grid reliability in certain areas. At the same time, climate change is increasing threats to electrical grid infrastructure across the nation.[1]

Along with threats to grid infrastructure come opportunities to improve grid resilience. More resilient electrical grids would be better equipped to respond to extreme weather events including wildfires and hurricanes, minimizing power outages and other disruptions to communities. A range of strategies exists to address grid vulnerabilities and improve resilience, ranging from physical improvements to traditional grid infrastructure to reimagining more distributed and decentralized energy systems.

This report presents two case studies of grid resilience in 2020, providing a factual overview of the unique threats to and opportunities for electrical grids in California and New York. While each state faces its own challenges, both coastal jurisdictions are responding to historic grid challenges in a context mired by increasingly severe climatic impacts. Policymakers and utilities in both states are experimenting with a variety of approaches to grid resilience.

Some of the strategies that appear most promising and effective include:

- Expanding renewable distributed energy resources, especially microgrids
- Policy and insurance reform to reduce development and encourage residential safety measures in high-risk areas, incentivize utilities to invest in preventative grid resilience measures, and support microgrid development
- Energy efficiency and demand management initiatives

Both states have underlying disparities in energy access and reliability that make certain communities far more vulnerable to climatic hazards and corresponding grid threats than others. Some approaches to improving grid resilience are likely to exacerbate existing inequalities along socioeconomic, racial, and geographic lines, such as increasing the cost of liability insurance in high-risk areas or relying on laissez-faire microgrid development by affluent individuals. Others, including investing in programs to ensure low-income communities have access to renewable community microgrids, present opportunities to reimagine more equitable, community-oriented, and distributed energy systems. This report recommends that each jurisdiction acknowledge the equity implications of existing grid vulnerabilities and prioritize grid resilience strategies rooted in environmental justice and equity.

I. California's Grid Resilience Threats and Potential Solutions

California is battling twin threats of wildfires and the corresponding power outages that both result from, and are an attempt to reduce, such fires. While wildfires are not a new threat in California, they are becoming increasingly challenging to address as electrical grid and forest mismanagement, climate change, and residential development complicate and exacerbate the fires' human and economic toll.

Wildfires in California in recent years have been particularly deadly, with three "consecutive year[s] of catastrophic blazes."[2] The 2017 fire season—which brought 6,000 wildfires killing at least 46 people, destroying more than 10,000 structures, resulting in more than $10 billion in damages, and burning over one million acres—resulted in "historic levels of death and destruction."[3] That is, until 2018. The 2018 Camp Fire alone killed 85 people, burned close to 19,000 structures, caused $16.5 billion in damages, and destroyed the town of Paradise.[4] The smoke caused by these massive wildfires has also created significant air quality concerns for many communities across the state. The 2019 wildfire season was less deadly and destructive than in previous years, but still caused significant hardship, including through widespread evacuations and the use of preventative blackouts.[5]

To date, the approach of the state's largest utility, Pacific Gas & Electric Co. (PG&E),[6] to mitigate wildfires appears to have exacerbated existing grid reliability challenges. With 5,400,000 accountholders, covering roughly 16 million people,[7] the utility's decisions have tremendous ramifications and garner increasingly sharp public scrutiny.

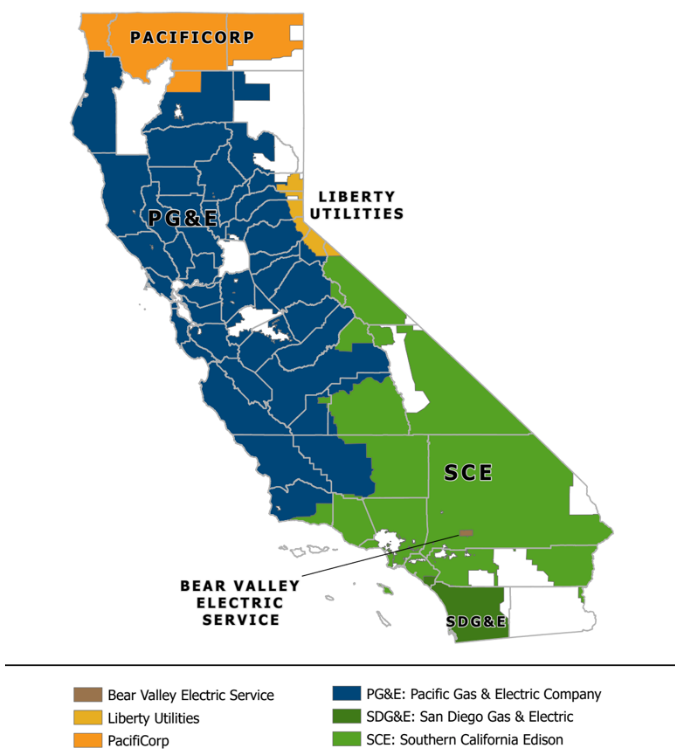

Figure 1: Map of California's Electric Investor-Owned Utility Service Areas in 2020. Source: California Energy Commission.

Because the causes contributing to wildfire risk and poor grid reliability are complex and decades in the making, there is no silver bullet solution to California's grid resilience challenges. A host of potential strategies is likely needed to reduce the risk of wildfires from grid equipment, mitigate the impacts of wildfires on the grid, and ensure communities across the state have more reliable access to energy. The potential solutions presented fall largely into the categories of (1) better managing grid infrastructure and surrounding vegetation, (2) physical upgrades to grid equipment, (3) improved situational awareness through advanced grid technology, (4) building a more distributed grid, and (5) land use policy and insurance reform.

The following case study provides an overview of existing threats to California's grid, potential strategies to improve grid resilience, and efforts to reform wildfire liability law. The state's unique wildfire liability scheme may simultaneously incentivize preventative wildfire safety measures and high-risk development, while reducing funds available to invest in wildfire prevention. The various strategies and reform efforts discussed throughout this report operate in the context of California's increasingly severe housing shortage as well as the contentious, lengthy bankruptcy proceedings of its largest electrical utility.

A. Threats to California's Electrical Grid

In 2020, California's electrical grid, energy customers, and communities face multiple threats related to safety and energy reliability. Two of the most prominent threats include deadly wildfires and decreased grid reliability through power outages,[8] both those arising from fire-related damage to the grid and in the form of public safety power shutoffs (PSPS).[9] Each of California's major utilities has used or considered using PSPS to manage the first threat, which directly increases the risk of the second threat for their customers.[10] This section explores several causes of this precarious situation and how each contributes to the grid threats Californians face.

1. Insufficient Investment in Grid Infrastructure

One of the most frequently discussed causes of California's high wildfire risk and resulting grid unreliability is ineffective management of grid infrastructure by the state's utilities, namely PG&E. The utility manages 100,000 miles of the state's 250,000 miles of distribution lines, in addition to 18,500 miles of transmission lines.[11] Many commentators blame the utility's "mismanagement of, chronic underinvestment in, and poor planning around its electricity system" for contributing to the prevalence of wildfires and associated risks to the grid.[12] In fact, the state's forestry department (Cal Fire) and the California Public Utility Commission (CPUC) have determined that PG&E's transmission lines caused the deadly Camp Fire of 2018.[13]

PG&E does appear to have underinvested in maintaining and modernizing grid infrastructure. These under-financed investments include trimming vegetation around transmission and distribution lines[14] to avoid brush falling on lines and sparking fires in windy and warm conditions,[15] as well as inspecting power lines and repairing aging grid equipment.[16] Others include replacing wooden utility poles with more fire-resistant materials such as steel,[17] insulating power lines[18] or burying them underground,[19] upgrading transformers, and installing technologies to help better detect and isolate grid problems.[20] While PG&E has announced plans to invest in several of these techniques,[21] many fault the utility for creating the context for much of California's wildfire risk due to its historic under-investment.[22] In contrast, San Diego Gas & Electric Co. (SDG&E) has invested in many such techniques to minimize wildfire risks.[23]

Some of the money PG&E could have invested in grid infrastructure appears to have been directed to more profit-oriented motives instead. In the last five years alone, the utility returned $4.5 billion in shareholder profits and has spent "millions" on state lobbying and paying bonuses to its executives.[24] PG&E was convicted in 2016 of safety violations related to a deadly gas pipeline explosion in San Bruno, California in 2010.[25] Judge Alsup, who is overseeing PG&E's criminal probation from this explosion,[26] stated at a 2019 hearing that "[a] lot of money went to dividends that should've gone to [trimming] trees" around the utility's power lines.[27]

Judge Alsup recently ordered PG&E to "overhaul" its approach to inspecting transmission lines, hire more inspectors to oversee tree trimming, and improve its record-keeping.[28] He noted that the current situation arose "because for years, in order to enlarge dividends, bonuses, and political contributions, PG&E cheated on maintenance of its grid — to the point that the grid became unsafe to operate during our annual high winds, so unsafe that the grid itself failed and ignited many catastrophic wildfires."[29]

Despite PG&E's historical approach to grid management, financial markets appear responsive to utilities' actions to respond to and plan for climate change impacts.[30] Utilities implementing resilience measures such as system hardening and efforts to mitigate greenhouse gas emissions "attract[] investors" and enjoy benefits in stock valuation, while utilities that "rely[] on business as usual discourage[] investors and increase[] stock price volatility."[31]

2. Climate Change

Although utilities have contributed to the high risk of wildfires, climate change is another force whose contributions are difficult to underestimate. By driving higher temperatures and increasing the frequency and duration of droughts,[32] climate change is exacerbating underlying wildfire risks.[33] Extreme heat from wildfires in turn increases conduction and can lead power lines to arc to the ground,[34] where they are more likely to touch brush and spark further fires or damage.[35] Climate change effects can also decrease the electrical grid's reliability and efficiency. Wildfires, made more likely by climate change, can damage transmission and distribution lines.[36] The grid also becomes less efficient at transmitting electricity as temperatures rise.[37]

Beyond its impacts on the electrical grid, climate change already brings disproportionate harms to California's low-income communities and communities of color, including through extreme heat and flooding.[38] These communities are often also most vulnerable to the grid threats discussed throughout this case study.

3. Poor Forest Management

Some also suggest that forest mismanagement by state authorities has worsened the dangers posed by rising temperatures and outdated infrastructure. California's electrical grid "is a sprawling network of aging power lines that overlaps with a landscape that is drier and more vulnerable to wildfires than ever before."[39] Many blame state authorities for insufficient forest management over the past several decades, including fire suppression efforts.[40] As a result, there are an estimated 147 million dead trees spread across the state.[41] These dried trees provide readily available fuel to any wildfires sparked by electrical grid infrastructure or human activity.

4. Development in the Wildland-Urban Interface

Another systemic contributor to California's wildfire risk is the rampant residential development in many areas of the state that are particularly prone to fires. About half of California's housing development is taking place in the wildland-urban interface (WUI),[42] increasing both the risks and ramifications of wildfires.[43] The California Department of Insurance estimates that 3.6 million homes exist in the state's WUI.[44] Two million homes in the state face high or extreme wildfire risks.[45] Wildfires are more likely to spread and cause damage in the WUI, as communities often lack fire preparedness and evacuation plans and many houses are built with materials that are not fire-resistant and are surrounded by flammable vegetation.[46] Among its millions of customers, PG&E supplies electricity to many residents who live in such "mountainous, forested areas growing hotter and dryer every year" as climate change progresses.[47] The physical reality of these environments makes it highly likely for utilities to either spark some wildfires in trying to deliver electricity, or to deliver electricity less reliably.

The forces driving development in the WUI are complex, including rising costs and decreasing availability of housing[48] and state incentives.[49] One challenge is that insurance premiums in such areas do not fully reflect actual risks of wildfire, so subsidized premiums enable development that does not fully account for such risks. State laws and regulations incentivize much of the development in the WUI and the manners in which it poses fire dangers. Yet, wildfires appear to be decreasing the availability and affordability of insurance in the WUI without properly accounting for wildfire mitigation measures, which may lead an increasing number of homeowners to "decide to go uninsured, risking their life savings and ultimately seeking relief from the state and federal governments."[50]

B. Options for Improving California's Grid Resilience

Addressing California's twin threats of wildfires and grid unreliability will likely require a mix of solutions.[51] The range of solutions largely fall into the categories of investing in the existing grid, creating a more distributed grid, and reducing development in areas of high fire risk. First, vegetation management and infrastructure inspections can reduce risks around existing grid infrastructure. Second, "grid hardening"[52] can decrease wildfire risks and improve resilience. Third, "grid softening"[53] strategies can enable faster detection and isolation of grid problems. Fourth, distributed energy holds the promise to increase local grid resilience while benefiting the overall grid. Fifth, changing land use and insurance policies may disincentivize development in areas of high fire danger.

Policymakers and utilities must weigh the benefits and drawbacks of each of these potential grid resilience approaches in the context of California's ambitious renewable energy procurement targets. California has committed to sourcing 60% of its electricity from renewable energy sources by 2030 and sourcing 100% of its energy from "zero-carbon" sources by 2045.[54] Shifting energy generation away from fossil fuel sources as quickly as possible is imperative to mitigate the worst impacts of climate change. At the same time, improving grid resilience will help communities across the state adapt to the ever-worsening impacts of climate change, including exacerbated wildfire risks. Thus, both goals—meeting or exceeding renewable energy procurement targets and improving grid resilience—are essential. However, as discussed below, some fossil fuel-based solutions that can improve grid resilience in the short term directly detract from the goal of moving toward a more renewable grid and thus would work against the state's climate change mitigation goals. Furthermore, directing taxpayer funds or utility resources toward meeting one goal may limit the resources available to meet the other goal. Policymakers and utilities should thus prioritize grid resilience solutions that simultaneously work toward the state's renewable energy goal.

1. Vegetation Management and Infrastructure Inspections

One of the most straightforward ways to minimize wildfire danger is to inspect and maintain the existing grid and its surroundings. This includes vegetation management to remove dead trees and brush from the vicinity of power lines[55] and minimize risks of brush falling on lines and sparking wildfires.[56] More frequent inspections of grid infrastructure may also help identify potential problems faster and avoid fires sparked by old and damaged infrastructure.[57]

Together, these approaches can address some of the threats posed by PG&E's under-investment in its grid infrastructure[58] and by state authorities' forest management.[59] Yet, there are 250,000 miles of distribution lines around California,[60] in addition to more than 25,000 miles of transmission lines.[61] This vast geographic span makes it costly for utilities to inspect infrastructure and manage vegetation fast enough to prevent most wildfire risks.

2. Grid Hardening Measures

Another category of solutions centers on physical improvements to grid infrastructure. For example, utilities can replace wooden utility poles and transmission towers with materials more resistant to fire, such as steel.[62] They can insulate power lines.[63] Utilities can also replace existing transformers with ones that use more fire-resistant fluids.[64]

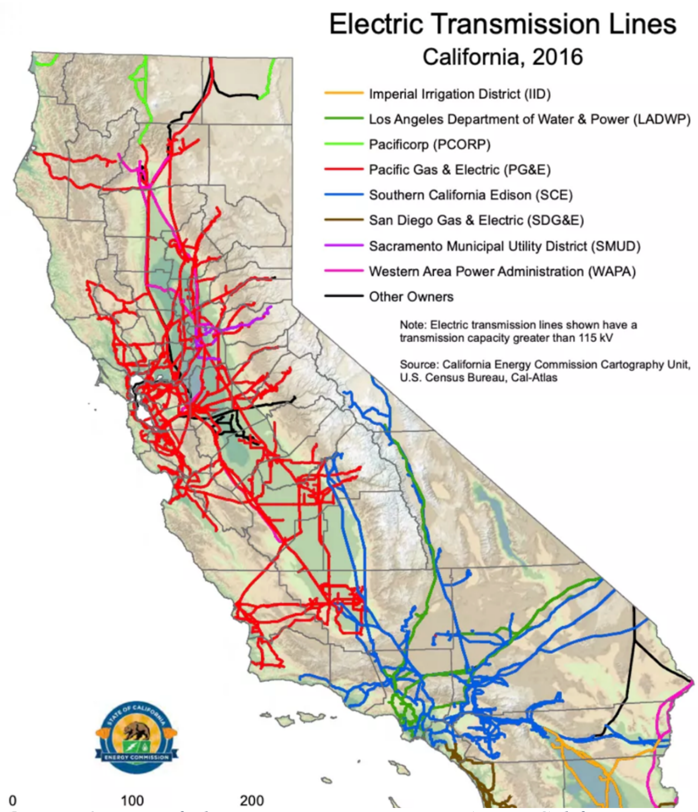

Figure 2: Map of Electric Transmission Lines Across California in 2016. Source: California Energy Commission.

One of the most effective grid hardening strategies is to bury power lines underground. "Undergrounding" power lines reduces their risk of sparking wildfires, although lines can still be damaged by earthquakes, animals, or severe weather.[65] Moreover, cost and implementation time are significant barriers to widespread undergrounding. PG&E says it would cost $3 million per mile to underground its lines, which would lead to a $15,000 increase on each customer's utility bill to underground all of its distribution lines alone.[66] Thus, many recommend a strategy of selective undergrounding to target power lines in areas of highest wildfire risk.[67]

PG&E has committed $5.3 billion to grid hardening efforts.[68] However, the CPUC's Wildfire Safety Division has expressed concern about the effectiveness of PG&E's commitments in actually reducing risks of wildfires and likelihood of reliance on PSPS. Regulators have emphasized the need for PG&E to invest in modeling to determine risks, strategically prioritize vegetation removal and other efforts by location, and improve its inspections.

3. Grid Softening and Situational Awareness Measures

Another solution to improve grid resilience and decrease the impact of wildfires is to make the electrical grid more responsive through grid softening or "situational awareness."[69] Various kinds of technology, such as synchrophasors, can make it easier to detect and isolate problems on parts of the grid without affecting the rest of the grid.[70] High-definition cameras, drone sensors, satellites, and other artificial intelligence systems can help grid operators better monitor and address problems such as wildfires.[71] Adding weather stations can provide more localized information on wildfire risks,[72] while investing in wildfire modeling technologies can help utilities better predict the risk and spread of fires.[73]

4. *Distributed Energy and Microgrids*

One of the most promising solutions for increasing grid resilience with rising wildfire risks is distributed energy. In fact, some consider a more distributed grid to be "the only true long-term solution to the wildfire mess."[74]

a. *The State of Microgrids in California*

Although an increasing number of Californians have installed solar panels on their homes, only 10% have storage, which is required to create a microgrid with solar energy. Most currently available residential batteries can power an average home for about one and a half days. Further, large economic and racial disparities exist in access to rooftop solar installations across the United States. A 2019 study found that rooftop solar installations were significantly lower in predominantly Black and Hispanic census tracts, and somewhat lower in predominantly Asian census tracks, than their white counterparts, even after accounting for home ownership and household income.[75]

Another option is to use electric vehicles (EVs) as battery storage.[76] The batteries in most EVs are large enough to power a typical home for several days "and still have enough power to drive away if needed."[77] However, most EVs only have one-way inverters and lack the ability to transfer power in two directions with solar panels, which is needed to island such systems off from the grid. Yet, with vehicle-to-grid technology, EVs could become "bidirectional energy-storage and demand-shifting resources" as part of a viable microgrid.[78] In fact, the California Energy Commission has invested $30 million in the last five years researching vehicle-to-grid integration, including bidirectional batteries.[79] Some recommend that California restrict its EV incentives to vehicles with such equipment.[80] However, EVs are also not a realistic option for many low-income individuals or families.

> ***A Primer on Microgrids****
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> Instead of centralized electricity generation and transfer over long distances through transmission and distribution lines, distributed energy enables local areas to generate, store, and manage their own electricity without transmission lines. Depending on the type of energy generated and the technology involved, users may be able to "island" off of, or separate their energy supply from, the central grid. An energy system that can island off the grid is considered a microgrid, or "a miniature, semi-independent grid of its own." Microgrids are particularly useful to improve local grid resilience when there are power outages on the main grid. They are also faster to install than power plants or lines. While distributed energy resources also include battery and other forms of storage, distributed solar energy generation, energy management for buildings, and other technology, this report focuses primarily on microgrids, which several experts and commentators highlight as a key opportunity to improve grid resilience in both California and New York.
>
> A microgrid can be as small as a single home or building, or it can encompass a group of structures such as an entire neighborhood or community. Because distributed energy "scales smoothly to any size," individual microgrids can be connected or networked together with others to create a community microgrid. Community microgrids can supply some electricity to whole communities, including shared facilities, and often "keep critical loads online indefinitely during power outages of any length." Microgrids can either fully defect from the grid or partially defect, which is more cost-effective and easier, by generating 80 to 90% of their own energy.
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> **Sources for this section are included in the references list at the end of this report.*

b. *Benefits to California's Grid*

Broader use of distributed energy could bring many benefits to California's grid, in addition to providing users with a more reliable power supply. First, microgrids improve the grid's ability to be modular and shut off power only to specific areas based on wildfire risk, rather than shutting off large expanses of the grid through

PSPS.[81] Renewable energy-powered microgrids can also reduce the greenhouse gas emissions emitted by and cost of operating the grid.[82] Microgrids can further improve the grid's stability and resilience year-round, as they are typically connected to the grid unless islanded off during power outages.[83] They can minimize the need for transmission infrastructure and "reliev[e] transmission bottlenecks,"[84] balance voltage and frequency, and help with "peak shaving," reducing the need for extra infrastructure to meet peak demand that is often underused.[85] Microgrids can also support demand response and take pressure off of existing power lines, which would itself help reduce fire risks.

c. Barriers to Implementation

There are, however, barriers to widespread adoption of distributed energy, particularly in the form of solar plus storage. First, although costs are decreasing, installing solar panels and investing in either residential batteries or EVs as storage is too expensive for many households.[86] The funds and expertise required to deploy community microgrids are also beyond the resources of many California localities.[87] In addition to installation costs, electricity from microgrids is typically more expensive than power from the central grid on a cost-per-kilowatt-hour basis.[88] However, this metric does not consider the many added benefits to the grid that microgrids provide. Proponents of distributed energy advocate for fully compensating and monetizing the grid services community microgrids provide to help finance the needed infrastructure investments.[89] When fully compensated, microgrids "can compete with the cost of grid power and vastly undercut diesel generators," while aiding local economic development.[90]

Second, some independent energy systems experts say that California lacks a sufficiently comprehensive strategy for deploying distributed energy.[91] Scaling up the amount of microgrids needed for true grid resilience with increasing wildfires will likely require state regulation in collaboration with utilities. Such a strategy would also provide more regulatory certainty for utilities, local governments, and private companies.

Finally, it is currently challenging and time consuming for microgrids to connect to utility infrastructure. A recent California Energy Commission study found "interconnection practices with host distribution utilities" to be one of the main barriers to microgrid deployment.[92] At this point, it is often "irrationally costly and time-consuming" to connect small microgrids to utility

As microgrids center generation near where power is used, they can also increase efficiency by reducing transmission "line loss." Furthermore, they can ensure that critical facilities such as hospitals, fire stations, or emergency call centers do not lose power during storms, fires, or other events that threaten the grid. Thus, microgrids can serve an important public health role in climate change adaptation. In addition to helping users, microgrids can benefit utilities by reducing peak demand on the central grid, providing power and voltage control, and improving cybersecurity. However, some urge that the benefits of microgrids should be quantified and balanced with their costs in order to most benefit consumers. Microgrid costs can include "design and planning expenses, capital investments, operation and maintenance, and environmental costs."

Microgrids can use various sources of energy, including fossil fuel-based or renewable energy. The traditional model uses diesel generators. Diesel is widely available and reliable as a microgrid energy source. Yet, diesel generators create local air pollution, need continued access to fuel supply, and can fail when only used irregularly for emergencies and outages. Thus, their widespread use would not only frustrate climate mitigation efforts but would also threaten local communities with health risks. A cleaner way to create a microgrid is by using solar energy paired with battery storage. Creating a microgrid with solar energy requires some form of energy storage. However, there is some debate as to whether microgrids using renewable energy are more or less resilient than those relying on fossil fuel sources such as natural gas.

infrastructure, but there are pilot projects underway to improve this process.[93] The state legislature also passed S.B. 1339 in 2018 to streamline microgrid interconnection with utilities.[94]

Despite these barriers, there are signs of progress toward integration of microgrids across California. The CPUC is encouraging utilities to invest in microgrids, and one of its proceedings will help "determine how to promote investments in microgrid development within a regulatory framework, while protecting risks and costs to ratepayers" of such projects.[95] California utilities have surpassed their goal of expanding energy storage capacity by 1.3 gigawatts in 2020.[96] In May 2020, PG&E committed to five battery storage projects, totaling 420 megawatts of storage capacity, from power sources including solar and geothermal energy. Southern California Edison Co. (SCE) similarly signed contracts for seven projects that will create 770 megawatts of storage capacity. Furthermore, the California legislature is currently considering a bill that would create a fund to support energy resiliency projects, including microgrids, prioritizing "communities . . . in vulnerable transition areas or in high fire-risk areas."[97]

d. Equity Implications

Distributed energy offers the potential to democratize the energy system, as it "puts more power, both electrical and political, in local hands."[98] If resources are invested to enable those most at risk of wildfires and outages to participate, distributed energy may make the benefits of grid resilience and harms associated with wildfires more equitable, and lessen PSPS impacts.[99]

However, given the current costs of solar panels and energy storage, without sufficient investment microgrids could become inequitably distributed across the state. This could result in a situation where higher-income individuals and communities reap the benefits of solar-powered microgrids, while middle-income residents rely on diesel generators that create air pollution and "lower-income families go without electricity for multiple days a year" as PSPS continue.[100] Lower-income Californians already face high energy burdens, with home energy costs totaling at least 6% of household income and nearly 10% in some areas.[101] A recent study found that low-income communities in Los Angeles County already use only about half the amount of electricity and natural gas as do surrounding wealthier communities.[102] The South Coast Air Quality Pollution Control District found that during the fall 2019 PSPS, diesel generators used in the Los Angeles and Orange County produced "more toxic emissions . . . than the largest petroleum refineries in the region."[103] The often decades-old generators emitted six tons of nitrogen oxides per day during the PSPS outages, which contributes to smog and acid rain and compounds asthma risks. If higher-income customers switch to renewable microgrids, this will also reduce the pressure to "keep[] grid power reliable and cheap," further harming the lowest-income energy customers.[104] California legislators are considering several wildfire-related bills this session, including bills to provide tax credits for purchases of generators.[105]

The CPUC seems aware of some of these equity concerns. In January 2020, the Commission decided to dedicate 63% of its $1.2 billion Self-Generation Incentive Program budget until 2024 to its "equity resilience budget" aimed at low-income, disadvantaged, or medically vulnerable residents living in areas of high fire risk.[106] These funds will in part help increase incentives for solar plus storage systems for those who face the highest risks of wildfires and PSPS.[107] California legislators might consider increasing funding available to the CPUC to expand the Self-Generation Incentive Program and other equity-focused initiatives, perhaps through the greenhouse gas reduction fund of proceeds from the state's cap-and-trade program auctions.[108] However, revenue from such auctions is expected to decrease significantly in 2020 due to the economic downturn associated with the COVID-19 pandemic, as with many sources of state revenue, so there may not be funds available from that source in the short term.[109]

5. Land Use and Insurance Reform

To address the threats posed by development in areas of high fire danger, some degree of land use policy reform will likely be needed. This involves addressing the more complex issue of California's housing shortage, which is "sending people out of cities into remote, forested areas."[110] The state could prohibit development in the WUI, but this would be politically unpopular, especially given California's already extreme housing supply shortage.[111] However, most commentators urge some reform to state laws and regulations that incentivize such development to address the state's severe wildfire risks.[112] In a 2019 survey about managed retreat, a majority of respondents supported some restriction of development in areas of high fire risk.[113] Effectively limiting development in the WUI will require increasing the supply and affordability of housing elsewhere in the state, primarily in cities.[114]

Similarly, adjusting insurance rates to better reflect real risks of wildfire would help reduce incentives for development in the WUI. Removing insurance subsidies would enable rates "to reflect the true risks of living in fire-prone areas."[115] Yet, making liability insurance more expensive in areas of high fire risk raises equity concerns, especially if residents of those areas cannot afford to live in less risky areas of the state. Some recommend the state address equity concerns by providing insurance subsidies only to low-income homeowners.[116] In the 2019 survey, most disfavored a policy requiring homeowners in high-risk areas to buy insurance.[117] The California Department of Insurance found that some major insurers have stopped renewing or adding plans and that "[p]remiums and wildfire surcharges have increased significantly in the WUI," while at the same time many "insurers do not take into consideration wildfire mitigation conducted by homeowners or the community."[118] The Department recommended that the state legislature implement a framework for insurers to better factor mitigation measures into premiums and to stabilize rates so "homeowners' insurance rates and premiums are adequate, but not excessive, for the true wildfire risk."[119]

Other types of land use reform could also help minimize the risks of wildfires in the WUI. For example, building codes or other regulations could require developers to construct homes and buildings with fire-resistant materials and require homeowners to remove flammable materials from their properties.[120] In 2019, however, Governor Newsom vetoed A.B. 1516, which would have required homeowners in the WUI to create "defensible space" to protect their homes from wildfires.[121] The governor acknowledged that defensible space, home hardening measures, and vegetation management are "critical components" to increasing wildfire resilience in the WUI but critiqued the bill for taking too broad of an approach without considering needs of particular communities.[122]

Another option would be for state or federal fire authorities to use prescribed burns to clear dead, dry trees that fuel wildfires in the WUI.[123] Most respondents in the 2019 survey supported increased use of prescribed burns to manage wildfire risks.[124] California legislators are considering a bill this session that would provide tax breaks for middle-income homeowners in areas of high fire risk who take measures to protect their homes from wildfires, including vegetation thinning, creating defensible space, and using more fire-resistant roofing materials.[125] A similar bill providing tax breaks to low-income homeowners who adopt fire-safety measures was enacted in 2019.

6. Solutions California Utilities are Currently Pursuing

One of the most controversial approaches California's major utilities rely on to limit wildfire risks is widespread use of PSPS. In 2018 and 2019, PG&E relied extensively on PSPS to help manage wildfire risks.[126] Its PSPS in October 2019 left 738,000 customers without power, with less than 24 hours of notice, affecting about 2 million people in "planned, deliberate blackout[s] unprecedented in the history of the nation's electrical system."[127] The utility foresees continuing to use frequent PSPS until 2030.[128] While PSPS can help to manage wildfire risks, they also create other risks and harms to communities and utility customers.[129] For instance, customers who lose power through PSPS can experience food spoilage, loss of business income, and property damage.[130] These outages affected the state's lowest income communities particularly severely, as residents reported not being able to afford replacing spoiled food, children losing access to school meals, and missed paychecks threatening ability to pay for rent or medical needs.[131] PSPS also create health risks for those who depend on electricity to power medical equipment or to refrigerate medication, such as for diabetes.[132] In 2019, the California legislature passed bills to require utilities to develop wildfire mitigation plans that take into account the medical needs of customers during PSPS[133] and to develop protocols for providing advance notice to public safety offices and health care providers before deploying PSPS.[134]

CPUC regulations allow utilities to use PSPS as part of their wildfire mitigation strategies, but its regulations do not provide utilities with much guidance or restriction on when or how they choose to shut off power.[135] PG&E says it considers several factors when deciding to undertake PSPS but provides no publicly-available metric or cutoff for making such decisions. In 2019, the utility's then-chief executive officer and president stated that PSPS were likely to continue over the next decade as the utility works to improve and repair its infrastructure.[136]

a. PG&E's Commitments

In response to the public uproar over its use of PSPS in the fall of 2019 coupled with continued wildfires,[137] PG&E has committed to update its grid management in several ways to decrease wildfire risks. First, the utility's 2019 Wildfire Safety Plan explains that its wildfire reduction "efforts [will] include significant expansions in its PSPS program,"[138] which will decrease grid reliability for customers. PG&E also commits to increased vegetation management and inspections of infrastructure such as distribution lines, transmission structures, and substations. The utility promises to expand its "situational awareness capabilities,"[139] including installing more high-definition cameras and building weather stations every twenty miles to provide more localized warnings.[140] Further, PG&E plans to use system hardening measures such as covering conductors, "select undergrounding," replacing outdated equipment, upgrading transformers to use more fire-resistant fluids, and installing more fire resistant poles.[141]

PG&E is also expanding its use of distributed energy by creating temporary microgrids in service areas prone to power outages.[142] So far, it "has relied exclusively on diesel" to fuel these microgrids.[143] The utility has recognized that diesel generation is not ideal but supports its choice of using diesel because of the fuel's "widespread availability" and "functional capability," while indicating it is considering other options like natural gas. In December 2019, PG&E requested bids from all types of energy suppliers to create permanent microgrids. A spokesperson said that the utility hopes to eventually be able to use solar, battery storage, and other renewable energy technologies but that there are challenges to doing so, pointing to the need to either use a "very large PV array to meet demands during shut-offs," or rely on fossil fuel energy as a back-up.[144]

Yet, after soliciting bids for permanent microgrids, PG&E found that the high costs and complexities surrounding deployment of permanent microgrids meant that only temporary microgrids are "financially viable."[145] PG&E stated that the costs and fast approach of the 2020 wildfire season require it to focus on temporary and fossil-fuel-powered microgrids for this year. However, many clean energy advocates point out that PG&E did not make clear in its CPUC filing that its use of fossil fuel generators will be temporary.

In January 2020, PG&E told Judge Alsup, who is overseeing its criminal probation related to the 2010 gas pipeline explosion, that it is working toward—but not quite on track to meet—the targets listed in its probation.[146] The utility admitted to not meeting its own safety plan commitments for inspecting and repairing power lines, clearing vegetation, and cutting tree branches near power lines.[147] However, it reported full success with wildfire safety inspections and some categories of grid hardening.

The COVID-19 pandemic has further complicated utilities' efforts to address California's wildfire risks. Social distancing measures may limit firefighting capacity and preventative measures such as vegetation trimming, controlled burns, and grid hardening.[148] PG&E anticipates a challenging wildfire season and continued use of PSPS in 2020, although it aims for each PSPS to be shorter and to affect one-third fewer customers than in 2019.[149] The utility aims to shorten power restoration times by 50%, and is installing grid technology to help it reduce the size of each PSPS.[150]

b. SCE's Approach

Similarly to PG&E, SCE has stated that it will focus on temporary and fossil-fuel-powered microgrids for this year because of the high costs of developing permanent microgrids and the impending 2020 wildfire season.[151] In the place of microgrids, the southern California utility plans to prioritize grid hardening measures, including covering conductors, and augment its ability to shut off smaller portions of the grid at a time.

c. SDG&E's Efforts

SDG&E appears to be far ahead of PG&E in its wildfire prevention efforts. After a court found that SDG&E's insufficient vegetation management caused several 2007 wildfires, the utility settled related claims for $2.4 billion.[152] SDG&E then spent $1.5 billion "upgrading its fire detection and response capabilities." It has proposed to spend another $3 million on "aggressive grid hardening," vegetation management, grid softening measures like weather stations and high-definition cameras, and community outreach and resource centers. SDG&E also plans to begin using satellites this year to track wildfires.[153] The utility has told the CPUC that it intends to increase its microgrid capacity in 2020.[154]

7. Summary of California's Grid Resilience Options

As the causes of California's precarious wildfire situation are complex, a variety of solutions will likely need to be pursued to minimize wildfire risks and maximize grid resilience. In the short term, utilities should invest in the existing grid through a mix of vegetation management, inspections, grid hardening, and grid softening to limit risks of wildfires from grid infrastructure and improve grid resilience. In addition, widespread deployment of distributed energy could increase resilience for communities in areas of high fire danger, while limiting some wildfire risks. Finally, changing land use policies and insurance subsidies could limit development in the WUI. This approach is likely the most complex and political challenging, but it may be needed to effectively reduce wildfire risks and avoid inequities in PSPS impacts.

C. Wildfire Liability in California

Another major piece of California's grid resilience picture is the state's wildfire liability scheme. The liability utilities face from wildfires caused by their equipment can serve as a mechanism to incentivize utilities to invest more extensively in preventative wildfire safety measures. At the same time, when utilities are found liable for massive, several-billion-dollar wildfires, it limits utility funds available for investing in further wildfire prevention and climate change mitigation measures and can hinder energy affordability for customers. Furthermore, as discussed above, there are several overlapping contributors to California's wildfire vulnerability, including underinvestment by utilities but also climate change, forest management, and expansive development in the WUI. The availability of compensation under the current liability scheme may further contribute to incentivizing high-risk development in the WUI.

Wildfires in California over the past few years have resulted in enormous amounts of harm, including deaths, injuries, and substantial property damage.[155] PG&E faced extensive liability from such wildfires,[156] which led it to file for bankruptcy in 2019.[157] California's inverse condemnation doctrine governs much of the liability facing PG&E for recent wildfires. Several utilities and other stakeholders support efforts to replace the inverse condemnation scheme with a fault-based approach to liability. While the state has not followed these suggestions as of yet, it has created a wildfire compensation fund to help protect utilities from overwhelming liability from increasingly frequent wildfires.

1. California Law Applicable to Wildfire Liability

California's inverse condemnation doctrine enables the main form of liability utilities face after their equipment causes wildfires. The doctrine derives from Article I, Section 19 of the California Constitution,[158] which also enables eminent domain.[159] The primary policy goal underpinning the doctrine is to distribute the costs of making public improvements throughout society instead of imposing them solely on the individuals who experience associated harms.[160]

To succeed on a claim for inverse condemnation, plaintiffs must demonstrate that "a public entity has taken or damaged their property for a public use."[161] Such damage is compensable if it was substantially caused by a public use or improvement "as deliberately designed and constructed,"[162] unless it falls under two exceptions to the doctrine.[163] The first issue is whether private property was taken or damaged.[164] The second issue is whether the damage or taking was caused by a public use or improvement.[165] Inverse condemnation may not apply if a public entity damaged private property for a private use, such as to serve the property owners' own needs.[166] The third issue is whether the damage was done by a public entity, which includes privately-owned public utilities.[167] Courts have found "no rational basis" through which to distinguish publicly- and privately-owned electric utilities for inverse condemnation purposes.[168] If a plaintiff proves that a public entity took or damaged their property for public use, the next issue involves assessing just compensation.[169]

In addition, the California Health and Safety Code permits cost recovery from persons found to have negligently started fires. Section 13009(a)(1) of the Code states that a person who "negligently, or in violation of the law" starts a fire, allows a fire to be started, or allows such a fire to escape onto others' property "is liable for the fire suppression costs incurred in fighting the fire" as well as related emergency expenses.[170] A person who "willfully, negligently, or in violation of law" enables a fire to start or escape is also liable for any damage the fire causes to private or public property.[171] These provisions apply to electric and other utilities.[172]

2. *Reform Efforts*

Several of California's utilities urge the state to replace the inverse condemnation doctrine with a negligence or fault-based standard.[173] Some suggest that utilities should only be held liable for damages from wildfires "up to the point it harms ratepayers or impacts service."[174]

The California Commission on Catastrophic Wildfire Cost and Recovery supports replacing inverse condemnation with fault-based liability.[175] In its 2019 report, the Commission stated that the inverse condemnation doctrine "imperils the viability of the state's utilities, customers' access to affordable energy and clean water, and the state's climate and clean energy goals," while simultaneously failing to "equitably socialize the costs of utility-caused wildfires."[176] It also noted that the doctrine increases the risk of bankruptcy for utilities, which jeopardizes not only the utilities themselves but also wildfire victims and utility customers. The state legislature could replace the current application of inverse condemnation with a fault-based liability approach through legislation, without amending the state constitution.[177]

Others recommend a scheme to allow some utilities to access "bridge financing" for fire liability and cost recovery.[178] This suggested system would be available to "electricity providers who act responsibly" and in the public interest, considering factors of safety and affordability.

Another option is to create a fund for compensating wildfire victims to help "socialize wildfire costs" while preventing overwhelming liability for utilities.[179] In 2019, the California legislature approved a measure to create such a fund "to help the state's utilities erect a backstop against huge liability claims."[180] Utilities can file applications after paying or committing to pay claims, including those related to wildfires ignited on or after July 12, 2019 and deemed to have been caused by an electric utility.[181] As a "revolving liquidity fund," the Wildfire Fund will pay claims and then be reimbursed by electric utilities.[182] The fund will be "initially capitalized by a loan from the state's Surplus Money Investment Fund" and then partially funded by "initial" and "annual contributions" from electric utilities.[183] To be eligible to participate in the fund, electric utilities must have met several conditions by June 30, 2020, including wildfire safety provisions.[184] Of utmost relevance to PG&E, eligible utilities must have resolved any insolvency proceedings and received CPUC approval of any reorganization plan.[185]

Despite these liability reform ideas, many support the continued application of California's inverse condemnation doctrine to utility-related wildfires. Insurers, wildfire victim attorneys and advocates, and others support the doctrine as enabling the state to "hold[] utilities like PG&E responsible for years of lax safety management."[186]

3. PG&E Efforts to Address Potential Liability

As a result of the inverse condemnation doctrine, PG&E faced more than $30 billion in liability from recent wildfires, whether or not it was negligent.[187] This liability led the utility to file for Chapter 11 bankruptcy in 2019. In June 2020, a California state judge ordered PG&E to pay $3.49 million in criminal fines for causing the deadly and destructive 2018 Camp Fire.[188] PG&E had pled guilty to 84 counts of involuntary manslaughter and "one count of unlawfully and recklessly causing the fire as a result of its gross negligence in maintaining its power line." The CPUC also voted in May to impose nearly $2 billion in penalties against PG&E for the 2017 and 2018 wildfires caused by its equipment.[189]

Similarly, SDG&E was found liable for several 2007 wildfires based on its insufficient vegetation management.[190] The utility settled claims, including inverse condemnation claims, emanating from these wildfires for $2.4 billion.[191] It tried to distribute the remaining $379 million in costs to its ratepayers but failed to obtain CPUC approval,[192] and a state appellate court denied review.[193] Both the California Supreme Court and United States Supreme Court denied petitions for review of the appellate court's decision.[194]

a. Wildfire Liability and Settlement Efforts

In December 2019, PG&E reached a $13.5 billion settlement with victims of several major wildfires from 2015 to 2018, including the Camp Fire and Butte Fire.[195] Judge Montali, the federal bankruptcy judge overseeing PG&E's bankruptcy proceedings, approved this amended settlement, along with a proposed $11 billion settlement with PG&E's investors and insurers.[196] In March 2020, PG&E also reached a $1 billion settlement with the Federal Emergency Management Agency to reimburse the agency for disaster relief funds it spent to address the wildfires caused by PG&E equipment.[197]

Also in December 2019, the CPUC proposed a $1.675 billion settlement with PG&E related to wildfires sparked by the utility's equipment in 2017 and 2018.[198] The proposed settlement includes $1.625 billion in costs, which PG&E would be prohibited from passing on to its ratepayers, and $50 million in "system enhancements" and maintenance to mitigate wildfire risks.[199] In late February 2020, the CPUC amended the settlement amount to $2.137 billion, adding "$462 million in penalties and added benefits for PG&E customers."[200]

In late June 2020, Judge Montali approved PG&E's bankruptcy reorganization plan.[201] The plan will guide "the largest utility reorganization in U.S. history" and leaves PG&E with $40 billion in debt, including the $25.5 billion settlement of claims by those harmed by the wildfires, insurers, and governments.[202] After months of efforts, this final approval of the bankruptcy plan is just in time to enable PG&E to qualify for the state wildfire fund. The other "essential hurdle[]" for PG&E to qualify was met when the CPUC unanimously approved the plan in late May 2020.[203] CPUC President Marybel Batjer acknowledged the profound distrust many Californians have for PG&E, pointing to the utility's "years of mismanagement and failure to prioritize its customers' safety," but stated that the reorganization plan will create stronger oversight and accountability and changes in leadership. As part of the deal, PG&E agreed to change its governance structure, replace 11 of its 14 board members, and for its CEO to retire at the end of June.[204] The utility's lawyer assured Judge Montali that it had ensured the necessary financing to carry out the reorganization plan and would have sufficient funds to address potential claims from future wildfires.[205]

However, there is not universal support for the utility's bankruptcy plan. Some of those harmed by wildfires "denounced" PG&E's bankruptcy plan, in part because half of the victims' $13.5 billion settlement will come in the form of PG&E shares.[206] More than 85% of victims from the 2015, 2017, and 2018 wildfires voted to approve the plan, but others say the plan fails to adequately address the utility's larger wildfire risk and "push[es] the risks of the plan on to fire victims" by possibly preventing them from selling their stock for years.[207]

b. Liability for Public Safety Power Shutoffs

PG&E generally does not reimburse its customers for harms they suffer during PSPS.[208] The utility rejected all 146 claims customers filed in 2018 related to PSPS.[209] SDG&E responded similarly to PSPS claims. However, PG&E allows customers to file claims for non-PSPS power shutoffs and credits customers $25 per day for outages caused by emergencies such as storms. State officials have criticized PG&E's policy not to reimburse customers for PSPS-related damages. After Governor Newsom called on PG&E to reimburse customers for the fall 2019 PSPS, the utility agreed to do so for a select round of PSPS.[210] PG&E decided to credit customers who experienced PSPS between October 9 and 12, 2019, in part because of the utility's communication failures during this period, including website malfunctions and understaffed call centers. Yet, PG&E stated that it will not reimburse customers whose power was turned off in PSPS after October 12 as it was able to resolve its communication issues and because PSPS are a CPUC-approved wildfire prevention measure.

In March 2020, Judge Montali dismissed a lawsuit by PG&E customers seeking damages related to the impacts of the fall 2019 PSPS, which alleged that PG&E negligently failed to maintain its grid infrastructure "in such a manner that no such blackouts would be necessary."[211] Judge Montali found the claims preempted by California law and explained that holding utilities liable for the shutoffs would "interfere[] with the CPUC's exclusive regulatory authority" over PSPS.[212] However, he noted that the CPUC is still investigating California utilities' management of PSPS in fall 2019 and explained that any damages the plaintiffs suffered from the PSPS "must be addressed by the CPUC."[213] The California legislature is currently considering bills to require the CPUC to create a process for utilities to compensate customers and local governments affected by PSPS[214] and to establish rules for PSPS and determine whether utilities met the rules for PSPS events, with potential to require utilities to reimburse customer losses.[215]

D. Summary of California's Grid Threats and Opportunities

Equitably addressing California's precarious grid situation will require taking into account utilities' historical patterns of grid management, existing disparities in access to housing and energy, and the state's wildfire liability scheme. Californians face the dual risks of wildfires—whose impacts have been heightened by poor grid and forest management and the ever-increasing force of climate change—and preventative power outages. Utilities' attempts to mitigate the deadly and destructive risks of wildfires through expansive PSPS have left millions in the dark and created a whole new suite of risks to human health, livelihoods, and localities. Both threats highlight the vulnerability of California's grid to current challenges, particularly in its centralized form where outages affect large swaths of customers.

Accordingly, the most promising grid resilience solution appears to be investing in a more decentralized, community-oriented electrical grid. While utilities can and should invest in vegetation management, grid hardening, and grid softening measures across the grid to reduce severe wildfire risks, the solution with the most promise for reducing the impacts of outages both caused by wildfire destruction of grid infrastructure and in the form of PSPS is deployment of distributed energy resources such as microgrids. To avoid further contributing to climate change, which in turn fuels wildfire risks, and creating local air pollution risks, such microgrids should be powered by renewable energy.

Although there appears to be a consensus across many stakeholders that microgrids are a promising grid resilience strategy for California, there remain obstacles to their broad use. Enabling the expansion of renewable microgrids will require investments to enable all communities to access such resources, not merely individuals who can afford to install solar panels on their homes and purchase EVs or other storage options. Regulators and policymakers can aid in the expansion of microgrids by creating a comprehensive strategy of laws and regulations to provide more regulatory certainty and help facilitate interconnection with utilities.

But creating a more distributed grid will not decrease California's severe wildfire risks alone. Utilities, particularly PG&E, must overhaul their approach to grid management and properly invest in regular preventative measures to trim vegetation around power lines, repair and replace damaged equipment, and modernize grid infrastructure. It remains too soon to tell how effective the newly reorganized utility will be at mitigating fire risk without relying overwhelmingly on the PSPS that threaten its customers. PG&E appears to have made some promising strides and commitments to better manage grid threats, but it still faces a steep, uphill battle to redress the decades of choices that led to this precarious moment. Regulators and policymakers must not only stringently oversee the reorganized utility's reform efforts, but also enact policies and expand programs aimed at reducing other contributors to California's grid threats and corresponding impacts on vulnerable communities. There is an important role for policy and insurance reform to address some of the systemic challenges that contribute to the state's wildfire risk, including forest management and development in the WUI.

It may also be worth considering various proposals to reform state wildfire liability law. As the highly contentious and nearly eighteen-month-long process of reorganizing PG&E has illustrated, the current inverse liability doctrine creates massive liabilities for utilities that can lead to bankruptcy. California's inverse condemnation doctrine, which holds utilities strictly liable for wildfires caused by their equipment, can notably incentivize utilities to invest in preventative measures to mitigate wildfire risks and avoid liability. However, it may also lead to outcomes that leave utilities less able to invest in such measures or provide reliable and affordable energy to their customers. Accordingly, several stakeholders propose reforms to the state's wildfire liability law. These proposals deserve further study, with careful consideration of the impacts of any potential reform on the communities most at risk from wildfires, PSPS, and climate change, including low-income Californians, people of color, and rural communities.

On the opposite coast, New York faces distinct grid challenges but can benefit from many of the same grid resilience solutions as California. New York's primary grid threats differ from those in California, but they are similarly complicated by historical patterns of grid development and climate change. As with California, low-income communities and communities of color in New York are often the most vulnerable to both climate change and its impacts on the electrical grid. Promisingly, they are also on the forefront of many grid resilience efforts, including community microgrid development. The below case study explores New York's unique grid threats and resilience options, with some comparison to those in California.

II. New York's Grid Resilience Threats and Potential Solutions

New York City (NYC) faces pressing grid threats as a result of its aging and heavily centralized grid infrastructure, population density, and coastal location. While its main utility, Consolidated Edison, Inc. (Con Ed) is not nearly as condemned—or financially threatened—as PG&E, it also faces substantial critiques and demands to reform. Yet, climate change appears to pose more numerous and overlapping threats to New York's grid than it does to California's. NYC was ranked fourth in a list of the 25 American cities most affected by climate change.[216] Climate change is exacerbating many of NYC's inherent grid threats through sea level rise (SLR), severe storms, and extreme temperatures.

Like California, addressing New York's grid challenges will also likely require a mix of solutions, including grid hardening and grid softening strategies, expansion of distributed energy, and insurance and regulatory reform. As demonstrated in the aftermath of recent storms and power outages, NYC's grid threats affect low-income communities and communities of color most severely. There is a similar risk as in California that laissez-faire microgrid development will enable wealthier individuals to enjoy reliable power while leaving poorer communities without energy or heat for days or weeks at a time following major storms. Accordingly, the most promising strategies seek to equitably improve grid resilience.

New York's utilities are similarly investing in grid hardening and softening measures, and the state appears further ahead than California in expanding distributed energy resources. The state's utilities, policymakers, and communities have not been consumed by the task of a massive bankruptcy reorganization over the past two years. This has likely left more time and resources for these stakeholders to focus on other policy and regulatory reforms needed to expand distributed energy and incentivize grid resilience measures. New York also seems to have been spurred into action after Superstorm Sandy caused widespread damage in 2012, whereas California appears to have turned its focus to grid resilience later, largely as a reaction to major wildfires in the past three years. The following case study discusses some efforts across the state of New York but focuses primarily on threats and opportunities in NYC, whose grid and dense population are especially at risk from climate change impacts.

A. Threats to NYC's Electrical Grid

As demonstrated by Superstorm Sandy in 2012, NYC is particularly vulnerable to many of the threats climate change poses given its aging grid infrastructure, low-lying coastal location, and population density. First, several structural features of NYC's grid make it vulnerable to climatic threats. Second, SLR threatens grid infrastructure and stability, while exacerbating storm-related risks. Third, major storms pose threats through storm surge, heavy rains, and severe winds. Fourth, increasingly extreme temperatures threaten grid infrastructure through heat waves, drought, and cold temperatures.

1. *Structural Vulnerabilities*

NYC's grid is among the nation's oldest, dating back to the early twentieth century.[217] Much of the city's electricity is generated at old power plants along the waterfront in Queens,[218] built as early as the 1960s. Distribution lines are buried underground across Manhattan but lines remain above ground in boroughs including Brooklyn, Queens, and Staten Island.[219] As with many other areas, "deferred maintenance" of NYC's aging grid has compounded threats posed by climate change.[220] The city's "antiquated oil-burning power stations" in Queens also create local health hazards: the NYC Department of Health has found higher levels of air pollutants including particulate matter in Astoria and Long Island City, the densely-populated neighborhoods hosting the city's major power plants, than in the rest of the city or borough, which city councilmembers link to these neighborhoods' higher rates of asthma.[221]

Figure 3: Con Ed Service Map.

The city's grid faces "inherent exposures" because it is highly centralized and regionally connected.[222] NYC is unique in the density of its residential and commercial populations,[223] with more than 8.5 million residents.[224] This population "relies on one giant power grid run by a single supplier,"[225] as Con Ed provides electricity to almost all of the city.[226] The utility serves more than 3.3 million customers in NYC in addition to Westchester County through "the world's largest underground electrical distribution system."[227] This centralized grid is typical in the United States and would be hard to change given the city's high density, aging buildings, and limited space.[228] NYC's grid is also interconnected with other critical infrastructure in the city and region, including transit and water delivery.[229]

2. *Sea Level Rise*

While climate change threatens coastal areas worldwide, "[f]ew places on Earth are as vulnerable to sea-level rise" as NYC.[230] By 2050, the region's sea level is projected to rise by more than 2.5 feet.[231] If so, almost 25% of the city, including most of its power plants, would be in the floodplain of a major storm.[232] This poses threats to grid infrastructure and electricity delivery.[233] SLR will likely affect electricity production by causing equipment damage from saltwater corrosion and flooding.[234] Transmission equipment will be similarly threatened, leading to more frequent and longer power outages.

Despite these projections, development continues along the city's coastline. Many homes destroyed by Superstorm Sandy have been rebuilt on stilts with support from the city, in what some describe as an attempt to fight back rather than accommodate the ocean.[235] Furthermore, NYC's "industrial waterfront has been a primary venue for the city's renewal" and is becoming increasingly densely populated.[236] In 2019, Mayor Bill de Blasio announced a $10 billion proposal "to extend Manhattan's southern coastline into the East River as far as 500 [feet]."[237] This development pattern echoes concerns with development in California's WUI, as both forms of development increase the populations at risk from climate change impacts and complicate grid resilience efforts to address climatic risks.

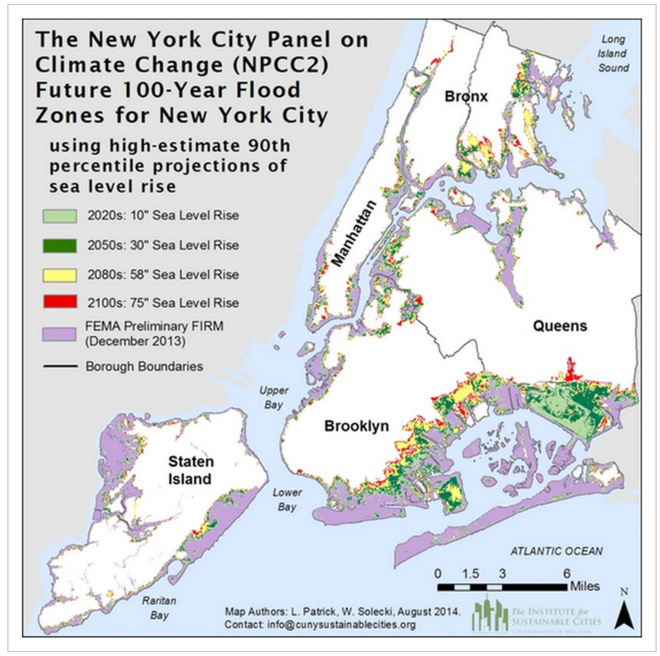

Figure 4: New York City Flood Zone Predictions. Source: New York City Panel on Climate Change.

Various options exist for the city to adapt to SLR, but many predict that "a new form of elevation-based inequality" will emerge.[238] Several of NYC's neighborhoods that are the most vulnerable to SLR-related disruptions also experience high poverty rates, public health problems, and environmental injustice.[239] Moreover, almost 20% of NYC's residential units within the floodplain are public housing units, where many residents already lack access to basic services. As in California, policy change to increase housing affordability in less risky and vulnerable parts of NYC are likely needed to effectively address these disparities.

3. Storm-Related Threats

Extreme weather events including hurricanes and other storms are becoming increasingly frequent and intense with climate change,[240] contributing to a rise in power outages.[241] Superstorm Sandy, which struck the east coast in 2012,[242] exemplifies many of the threats that major storms create for New York's grid through storm surge, heavy rains, and high winds.

a. Superstorm Sandy

Many describe Superstorm Sandy as a "wake-up call" about threats to NYC's grid in the face of climate change.[243] While hurricanes and snowstorms have "threatened utilities since the dawn of the electric era," Superstorm Sandy created unique threats to the grid due to its size, scope, and timing.[244] The storm resulted in a total of 285 deaths and $68 billion in damage.[245] It also deprived 8.5 million Americans across 21 states of power,[246] including 1,115,000 of Con Ed's customers in NYC and the surrounding region.[247] In addition, 1.1 million customers of the Long Island Power Authority (LIPA) lost power from Superstorm Sandy.[248] These power outages were caused by a mixture of flooded underground substations and damage to overhead power lines from high winds and fallen trees.[249] Superstorm Sandy also highlighted NYC's extreme inequalities in storm impacts and abilities to prepare for and recover from storms based on income and wealth disparities, including the ability to miss work, flee the storm by car, and pay for a hotel room.[250] As with residents in New Orleans after Hurricane Katrina, NYC's low-income residents "struggled disproportionately to repair their homes" after the storm.[251] The storm also far worsened existing needs for repairing public housing units, and more than 80,000 New Yorkers living in public housing went without electricity or elevators during the storm.

During the storm, Con Ed cut power to parts of the grid to prevent equipment damage in particularly vulnerable areas.[252] Nevertheless, one of its transformers in Manhattan exploded when an underground substation was submerged with saltwater.[253] The substation was built to resist a 12.5-foot storm surge, but Superstorm Sandy brought a 14-foot surge that flooded Lower Manhattan.[254] Overall, flooding led to power shutdowns at five substations, "disrupt[ing] a third of the city's electrical capacity."[255] The storm "caused catastrophic damage to critical underground systems causing many cascading effects to the electric system" and other interdependent infrastructure systems, including transit.[256] For instance, it flooded NYC's subway system, where clean-up was hindered as the pumps to remove water rely on electricity.[257] On Long Island, the storm damaged 44 LIPA substations.[258]

Con Ed was able to restore power to almost all of its customers within 12 days.[259] However, residents living in public housing units often had to wait more than two weeks for their power to be restored.[260] In this effort, Con Ed had to replace 140 miles of electrical cable and investigate 30,000 locations for damages.[261] The utility estimated needing to spend up to $450 million to repair storm-related damage to the grid.[262] LIPA had to replace more than 4,500 poles and 2,100 transformers and repair 400 miles of distribution lines after the storm.[263]

b. Storm Surge and Heavy Rains

Some of the most significant threats storms pose to the grid are in the form of flooding caused by storm surge or heavy rains. Much of New York State's electrical grid infrastructure, including power plants and substations, is in or near coastal areas and vulnerable to storm surge and flooding.[264] Storm surge can flood electrical generation, transmission, and distribution equipment, leading to power outages and equipment damage.[265] Saltwater's "corrosive effects" make it particularly harmful to electrical equipment.[266] The threats from storm surge are especially severe if nuclear plants are flooded and have their service pumps submerged, increasing the risk of disasters caused by loss of coolant.[267] In addition, heavy rains brought by severe storms can damage electrical production, transmission, and distribution equipment and contribute to power outages.[268] Once such equipment is repaired and floodwater is pumped out, the equipment must still be assessed and tested to ensure safety before restoring power.[269]

Some areas of NYC are more vulnerable to storm surge and flooding than others. For example, Hunts Point in the South Bronx, Red Hook in Brooklyn, and Edgemere in Queens are particularly vulnerable given their locations near waterfronts and the presence of toxic substances and landfills.[270] Edgemere, among the city's "most neglected neighborhoods," is especially at risk because of its location between Jamaica Bay and the Atlantic Ocean.[271]

c. High Winds

Winds brought by major storms create additional threats to the grid by causing damage to overhead power lines and power outages.[272] Extreme winds can disrupt power transmission and distribution by directly downing power lines or knocking down trees, which can fall on and damage lines.[273] Winds can also disrupt electricity production when utilities preventatively shut down generation facilities to avoid damage. As with underground equipment, downed overhead lines must be inspected and tested once repaired to ensure it is safe to restore power.[274]

Residents of boroughs with overhead power lines, including Brooklyn, Queens, and Staten Island, are particularly vulnerable to power outages caused by high winds from major storms.[275] During Superstorm Sandy, three-quarters of the region's overhead power lines were "crippled" from heavy winds and falling trees.[276]

4. Extreme Temperatures

Climate change is bringing increasingly frequent and severe heat waves, droughts, and cold temperatures.[277] Heat waves are projected to occur more frequently and be more extensive in the NYC region by the 2050s.[278] Given their ages and locations, NYC's power plants are highly susceptible to disruptions caused by severe weather.[279]

Extreme heat can cause direct damage to grid infrastructure and also increase demand while the grid's capacity decreases.[280] Heat can damage electrical circuits and cause transformers to explode.[281] The NYC Panel on Climate Change (NYCPCC) projects that "extreme heat periods" may increase the likelihood of power outages and equipment damage to the city's grid, while straining energy production equipment, materials, and performance and increasing maintenance needs.[282] Extreme heat can also cause overhead transmission lines to sag and increase downtime in electricity distribution. During a heat wave in July 2019, Con Ed intentionally shut off power to tens of thousands of customers in NYC to prevent equipment damage through overheating.[283] Furthermore, blackouts and brownouts are more likely in NYC during heat waves as "everyone cranks their air conditioning at the same time."[284] This puts pressure on the city's "older, less efficient generating stations [which] have a harder time keeping up" with demand.[285] Extreme heat events particularly burden low-income neighborhoods and communities of color, who often experience temperatures several degrees higher than those felt in other neighborhoods in many cities across the United States.[286]

Additionally, drought can compromise energy production, transmission, and distribution materials and processes, particularly those that depend on water.[287] Droughts can also jeopardize electrical equipment through increased likelihood of fires and decreased ability to fight fires.

On the other end of the spectrum, colder temperatures also threaten NYC's power grid.[288] "Cold snaps" can slow electrical production and transmission processes. Colder temperatures, snow, and ice can also damage electrical equipment that is not sufficiently insulated or protected. Low temperatures can further cause an increase in overhead transmission line sag and jeopardize underground lines through added exposure to freeze-thaw effects.

B. Options for Improving New York's Grid Resilience

A multitude of solutions exist to address the complex and overlapping threats New York's electrical grid faces. These resilience measures include grid hardening, grid softening, distributed energy, energy efficiency and demand management, and policy and regulatory changes. Since Superstorm Sandy wreaked havoc on New York's grid, several stakeholders including the state legislature, the New York Public Service Commission (PSC), NYC commissions, utilities, and environmental and community organizations have experimented with traditional and creative mechanisms for improving grid resilience. While the traditional approach first proposed by Con Ed focused primarily on grid hardening measures, a consensus appears to be emerging that promoting distributed energy and addressing barriers by changing policies and regulations hold the greatest promise for improving grid resilience across the state.

As with California, grid resilience opportunities for NYC operate in the context of ambitious renewable energy procurement targets for the state. New York's goals are even more ambitious than California's: it has committed to source 70% of its electricity from renewable sources by 2030 and to "transition the state to a carbon-free power grid by 2040."[289] Policymakers and utilities in New York, like those in California, must similarly balance these important goals with grid resilience goals and should consider using limited taxpayer funds and utility resources to best maximize both goals.

1. Grid Hardening Measures

One major way to improve the grid's resilience to climate impacts is through physical improvements to the grid, or grid hardening measures. While New York's climate-related threats are different than those facing California, some of the same grid hardening measures can help improve resilience in both states. In New York, grid hardening measures can similarly include burying distribution lines underground (to protect from storms and weather damage rather than to avoid igniting wildfires), but they can also include elevating substations and building levees or protective walls to protect infrastructure from storms, SLR, or other extreme weather.[290] Utilities have traditionally focused on methods including vegetation management around power lines and deploying sandbags to preventatively minimize damage to grid infrastructure from hurricanes and other storms.[291] After Superstorm Sandy, Con Ed estimated that "[f]ully stormproofing [its] system" would cost billions of dollars,[292] similarly to PG&E. Simply burying all of Con Ed's power lines underground would cost the utility approximately $40 billion.[293]

2. Grid Softening Measures

Another suite of solutions aims to improve resilience through grid softening, or increased flexibility, responsiveness, and situational awareness.[294] Many grid softening strategies rely on "smart grid" technology to communicate grid impacts and enable fast and localized responses. For NYC, a grid softening strategy could include prioritizing electricity to hospitals and senior living facilities particularly reliant on air conditioning during extreme heat waves. Con Ed has discussed other strategies to "improve flexibility" of its distribution system through smart grid technology.[295] Improving telecommunications infrastructure can also contribute to grid softening, and Con Ed acknowledges that "information about outages and reliability measures [is] crucial to implementing the most useful resiliency and storm hardening measures."[296] Again, albeit in response to threats such as hurricanes instead of wildfires, grid softening measures may similarly help Con Ed predict and isolate damage to grid infrastructure to smaller sections of the grid and minimize the impacts of outages, as with PG&E.

3. Distributed Energy and Microgrids

During Superstorm Sandy, a few microgrids in NYC enabled certain communities and systems to maintain a power supply while much of the city lost power. A microgrid at a New York University campus was able to island from the grid and continue powering larger buildings and essential operations during and after the storm.[297] Another microgrid at Co-Op City in the Bronx kept electricity running for 60,000 residents.[298] Many hospitals using distributed energy resources were able to "function[] normally" during and after the storm, including South Oaks Hospital in Amityville, New York, which islanded from the LIPA grid for two weeks by relying on its natural gas-powered engines.[299] Similarly, Nassau University's medical center and community college stayed powered "without any operational issues."[300]

Several other microgrids have emerged in New York since Superstorm Sandy. The NY Prize competition provided $40 million in funding to help develop at least 10 community microgrids serving communities of about 40,000 residents.[301] The New York Research and Development Authority (NYSERDA) managed the competition and involved utilities to help identify "opportunity zones" where microgrids would be most useful.[302] NYSERDA funded feasibility studies for 83 applications. Promisingly, the NYC Housing Authority is incorporating distributed energy sources into its resiliency program, including a "campus-scale microgrid" for more than 6,000 residents at its Red Hook Houses through gas-powered generators.[303] Red Hook is also developing a community microgrid, funded through NYSERDA and the New York Power Authority, which aims to primarily use solar and wind power.

a. Barriers to Implementation

Despite the strong promise that microgrids bring for improving New York's grid resilience, there remain barriers to their implementation—many of the same as in California. The primary barrier appears to be regulatory uncertainty surrounding distributed energy resources,[304] including a lack of a precise statewide definition of a microgrid.[305] The lack of regulatory certainty is a challenge in both New York and California. Furthermore, the traditional utility business model and goals may serve as obstacles to development of decentralized microgrids,[306] which is also the case for PG&E. There can also be high transactional costs and other cost effectiveness barriers involved in developing and deploying microgrids.[307] Finally, as in California, technological challenges exist related to microgrid interconnection with the central grid and maintenance.[308]

b. Equity Implications

Expanding distributed energy resources also raises important equity concerns. First, as described above, large racial disparities exist in installations of renewable energy sources such as rooftop solar panels.[309] Thus, there is a risk that microgrids will emerge to power affluent communities while leaving more vulnerable communities in the dark during and after major storms,[310] mirroring the risk of such a disparity in access to power during PSPS in California. However, it appears that the NYC Housing Authority is actively developing distributed energy for many of the city's public housing residents.[311] Furthermore, New York faces similar issues of "ratepayer equity," as customers with microgrids enjoy lower utility bills when using less grid power, which can in turn raise rates for customers without access to microgrids.[312]

4. Energy Efficiency and Demand Management

Energy efficiency and demand management measures can help reduce demand load, "making [the grid] more flexible and resilient."[313] Such measures include net metering, demand response, and rates adjusted for time of use.[314] Con Ed has a voluntary demand response management program in which participants can get discounted rates in exchange for enabling the utility to monitor their electricity usage and reduce it during peak demand times.[315] The utility has also installed battery storage systems in areas with high demand, including parts of Brooklyn and Queens. Con Ed plans to install the city's largest battery storage system in Brooklyn to help ensure reliability[316] by providing energy to match peak demand, decreasing transmission costs, and lowering electricity cost spikes by storing energy produced during non-peak times.

5. Insurance, Financing, and Regulatory Reform

Many stakeholders and commenters say that the major hurdles to improving grid resilience in New York center around policy reform rather than technology.[317] Potential areas of policy reform include changes to insurance incentives, financing measures, and regulations.

The NYCPCC identifies insurance and finance as "key dimensions in achieving infrastructure resilience."[318] Insurance mechanisms include reducing premiums for utilities that invest in preventive grid resilience measures to help incentivize such actions, as in California. However, other policies intended to help utilities and communities recover from storms can hinder the effectiveness of insurance and market-based mechanisms. For example, federal disaster assistance through the Stafford Act, while essential after a natural disaster, may "inhibit infrastructure resiliency" in the long term.[319] The availability of such disaster relief may disincentivize utilities from investing in measures to reduce damage from storms or purchasing insurance. Furthermore, such government relief typically only contributes to restoring the grid to its pre-storm status, as opposed to investing in improvements to better withstand future storms. The NYCPCC recommends several policy changes to enable insurance and financing methods to better incentivize resilience measures, including revising the Stafford Act, better linking insurance premiums to preventative measures, developing resilience metrics, and catastrophic risk data collection.[320] The Panel also suggests creative financing mechanisms including "catastrophe bonds" to help transfer risks to investors rather than taxpayers.[321]

Another category of solutions involves regulatory changes by the PSC and other state actors. The PSC has highlighted several issues that need to be addressed to better support microgrid deployment, including clarifying the applicability of tariffs.[322] New York's PSC appears to be further along in its efforts to support microgrid deployment than the CPUC, which is currently engaged in a proceeding to help develop a regulatory framework to promote microgrid development. Environmental organizations have encouraged the PSC to use rate incentives to help utilities develop distributed energy resources and to eliminate standby tariffs for such projects.[323] Improving regulatory certainty around microgrids would also enable more cost-effective development of such resources.[324] Other regulatory changes might include "changing net metering laws, removing franchise restrictions, and encouraging microgrid access to wholesale energy markets."[325]

While NYC does not face the same problem of rampant WUI development as does California, development is charging ahead in areas of the city particularly vulnerable to SLR and storm surge. It may also be worth considering land use policy changes to restrict development in high-risk areas and incentivize more resilient and equitable housing development in NYC.

6. Efforts in New York since Superstorm Sandy

After suffering severe impacts from Superstorm Sandy in 2012,[326] New York has emerged as one of the American states taking the largest strides to improve grid resilience.[327] A combination of statewide changes, NYC programs, and utility-driven efforts has led to decisions and funding to improve grid hardening, expand distributed energy, and update regulations. While this case study focuses primarily on NYC's grid threats, this section includes statewide efforts to improve grid resilience, which influence Con Ed and NYC initiatives.

a. State and City Initiatives

State bodies are proactively facilitating New York utilities' moves to improve resilience through regulatory changes and funding programs.[328] In passing the Climate Leadership and Community Protection Act in 2019, the state legislature established New York's ambitious climate change mitigation goals of achieving 70% of its electrical generation from renewable sources by 2030 and 100% from carbon-free sources by 2040.[329] To advance these goals and help improve grid resilience, Governor Cuomo in 2019 announced funding of up to $30 million for projects "to improve the resiliency, flexibility, and integration of renewable energy resources onto New York's electrical grid."[330] The program aims to help utilities address technical challenges related to transmission and distribution of renewable energy sources.[331]

In 2015, regulators launched the Reforming Energy Vision (REV) initiative to support development of distributed energy and grid resilience.[332] The REV proceedings are meant to help build a "plug-and-play grid," in which "the utility operates the distribution system as a platform that supports technologies" including rooftop solar panels, smart inverters, and energy storage.[333] The proceedings indicate the PSC's awareness of the resilience benefits of microgrids.[334]

Furthermore, the New York Independent System Operator (NYISO) has announced plans to help "bolster grid resilience" through its market products and services.[335] NYISO plans to incorporate a carbon price into energy markets in 2022, with efforts to support grid resilience and help incentivize "an increasingly diverse mix" of energy sources. It also plans to enable energy storage and distributed energy resources to participate in the wholesale energy market. Finally, NYISO is "considering procuring backup resources for grid resilience."

In the wake of Superstorm Sandy, NYC implemented several measures to improve its preparedness for extreme weather events.[336] For instance, the city updated its building codes to include further flood protection requirements and has developed several "emergency power systems resiliency measures," including through the NYC Housing Authority. The PlaNYC effort has outlined several efforts to advance microgrids in the city.[337] Some call it "the most important microgrid initiative in NYC," coming out of a special initiative former Mayor Michael Bloomberg launched in December 2012 to improve the city's resilience to storms.[338] PlaNYC has adopted a goal of achieving 800 megawatts of "new, clean" distributed energy resources in NYC by 2030.[339] Its 2013 report considered hundreds of initiatives, including community-specific plans, with a focus on microgrid deployment.[340]

b. Con Ed's Efforts

Con Ed has taken several steps to improve grid resilience since Superstorm Sandy. It began by requesting approval from the PSC for sizeable electricity rate increases to fund $250 million in "storm protection measures" and $1 billion in grid hardening improvements.[341] The utility also proposed grid softening and flexibility measures. A group of environmental organizations intervened in Con Ed's rate proceeding before the PSC to advocate for a more resilience-based approach, prioritizing distributed energy, rather than the mainly "conventional and established" grid hardening measures proposed by Con Ed.[342] The final PSC order "largely rejected the 'business as usual' approach" Con Ed proposed and instead required a strategy focusing more on grid resilience, including requiring the utility to pursue microgrids.[343] It also required all New York utilities to incorporate climate change adaptation into their system planning.[344] The PSC approved grid hardening measures for Con Ed focused primarily on substations, electricity and natural gas distribution systems, power plants, power lines, and tunnels.[345] The approved grid softening measures include a $6.6 million telecommunications infrastructure investment.[346] Con Ed has undertaken grid hardening at 20 of its affected substations, including elevated control rooms, perimeter walls, and digital control systems.[347]

Despite the massive investments approved by the PSC, some say Con Ed's "changes have not been swift"[348] and that the utility is "years behind schedule" in delivering on a PSC-ordered study on climate change vulnerability.[349] The PSC has repeatedly extended Con Ed's deadline for filing this report, and environmental groups say Con Ed has "dragged [its] feet."[350] While Con Ed spent $1.5 billion in 2018 to upgrade transformers, replace underground cables, and build battery stations, some say these expenditures were mostly for routine maintenance.

C. Summary of New York's Grid Threats and Opportunities

As with California, centering considerations of equity in NYC's grid resilience approach will not only make its resilience efforts more just, but also help address some of the city's preexisting inequalities in climate change vulnerability and access to energy. New Yorkers face unique grid threats from climate change given the city's low-lying coastal location, aging and heavily centralized grid, and high population density. Climate change seems to bring a greater range of grid threats to New York than to California, with NYC exposed to more frequent and intense storms, rapidly rising sea levels, and extreme temperatures on both ends of the spectrum.

Since Superstorm Sandy severely damaged New York's grid, stakeholders across the state have experimented with both traditional and creative mechanisms for improving grid resilience. While the traditional approach first proposed by Con Ed focused primarily on grid hardening measures, a consensus appears to be emerging that promoting distributed energy and addressing barriers by changing policies and regulations hold the greatest promise for improving grid resilience across the state.

New York appears to be further ahead than California in advancing grid resilience, particularly in terms of microgrid deployment and policy and regulatory reform. Yet, as in California, barriers remain in terms of providing sufficient regulatory certainty for microgrid expansion and ensuring that distributed energy resources are equitably allocated. On both coasts, expanding microgrid deployment alone will not suffice to mitigate grid threats. Con Ed must continue to invest in grid hardening and softening measures, while expanding distributed energy, to make its grid more resilient and responsive. And as in California, New York State and NYC policymakers should center the needs of low-income communities, communities of color, and other communities most vulnerable to the state's grid threats and climate change impacts as they continue to pursue a grid resilience strategy for the twenty-first century.

Conclusion: Prioritizing Equity While Reimagining Grid Resilience

On opposite coasts, and each facing their own climate change impacts and grid threats, California and New York share a common urgency to invest in grid resilience. New York utilities, policymakers, and regulators appear to have awakened to this urgency a few years ahead of those in California, although activists and advocates in both states have long been calling attention to the need to address climate change vulnerabilities and disparities in energy access.

Both coastal jurisdictions deal in extremes, with abundant wealth and investment accompanying profound inequities in access to housing, reliable energy, clean air, and other essential resources. Each faces a choice between pursuing grid resilience strategies that will deepen these disparities and those that will advance environmental justice by redistributing and democratizing access to clean and reliable energy. While both states face tremendous threats and challenges related to grid reliability, they also face tremendous opportunities to reimagine their electrical grids in ways that are more equitable, more community-centered, and more resilient to current and future threats.

There is no silver bullet to swiftly achieve grid resilience in either California or NYC. The threats facing each grid are complex and overlapping. They are rooted in decades- or century-old grid infrastructure and management practices. And these varied threats evolve as climate change worsens. As elsewhere, California and New York will need to commit to an ongoing and iterative effort to implement a range of grid resilience strategies and incorporate feedback on which strategies are effective, and which have unintended consequences.

What's more, grid resilience is not likely to be achieved through a solely top-down approach determined by a single utility or governmental body. To be truly effective and sustainable, grid resilience efforts must incorporate and respond to input and critiques from diverse stakeholders, including wildfire victims, neighborhoods most impacted by hurricanes, grassroots organizations, those living near polluting industrial sites, both urban and rural communities, and academics and renewable energy experts, to name a few. Because electrical grids are used (to varying degrees) by all Californians and all New Yorkers, policymakers and utilities should factor in the equity implications and opportunities of any potential grid resilience strategies they consider. And the voices of low-income communities and communities of color—who are often most jeopardized by climatic and grid threats and just as often left out of policy decisions that affect them—must be front and center for such strategies to avoid deepening existing inequities and instead truly achieve grid resilience for all.

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[54] S.B. 100, Ch. 312, 2017–18 Leg. Sess. (Cal. 2018) (setting the 60% renewable energy by 2030 and 100% "zero-carbon" energy by 2045 targets); *see also* Camila Domonoske, *California Sets Goal of 100 Percent Clean Electric Power by 2045*, NAT'L PUB. RADIO (Sept. 10, 2018), https://www.npr.org/2018/09/10/646373423/california-sets-goal-of-100-percent-renewable-electric-power-by-2045.

[55] *See* Colvin*, supra* note 16.
[56] *See* Cagle, *supra* note 7.
[57] *See* Colvin*, supra* note 16.
[58] *See* McNamara, *supra* note 2.
[59] *See* Colvin*, supra* note 16.
[60] *See* Roberts, *supra* note 11.
[61] Janet Wilson, *California power lines spark wildfires and prompt blackouts. Why not just bury them?*, USA TODAY (Oct. 11, 2019), https://www.usatoday.com/story/news/nation/2019/10/11/bury-california-power-lines-wildfire-blackout-fix-unlikely-work/3946935002/.
[62] *See* Roberts, *supra* note 11; Mulkern, *supra* note 17.
[63] *See* Roberts, *supra* note 11; Mulkern, *supra* note 17.
[64] *See* PAC. GAS & ELEC. CO., *supra* note 21 at 5.
[65] *See* Roberts, *supra* note 11.
[66] *See id.*
[67] *See, e.g.*, Roberts, *supra* note 11; McNamara, *supra* note 2.
[68] Emily C. Dooley, *California Regulator Cites Flaws in PG&E Wildfire Reduction Work*, BLOOMBERG (May 7, 2020), https://news.bloomberglaw.com/environment-and-energy/california-regulator-cites-flaws-in-pg-e-wildfire-reduction-work.
[69] *See* PAC. GAS & ELEC. CO., *supra* note 21 at 2.
[70] *See* Roberts, *supra* note 11.
[71] *See id.*; Mulkern, *supra* note 17; Colvin*, supra* note 16.
[72] *See* PAC. GAS & ELEC. CO., *supra* note 21 at 13.
[73] *See id.* at 4, 90; Roberts, *supra* note 11; Colvin*, supra* note 16.
[74] Roberts, *supra* note 11; *see also* Colvin, *supra* note 16.
[75] Deborah A. Sunter et al., *Disparities in rooftop photovoltaics deployment in the United States by race and ethnicity*, 2 NATURE SUSTAINABILITY 71 (2019).
[76] *See, e.g.*, Mulkern, *supra* note 17; David Roberts, *Wildfires and blackouts mean Californians need solar panels and microgrids*, VOX MEDIA (Oct. 28, 2019), https://www.vox.com/energy-and-environment/2019/10/28/20926446/california-grid-distributed-energy.
[77] *See* Mulkern, *supra* note 17.
[78] *See* Roberts, *supra* note 76.
[79] However, there remain many questions and challenges around deploying such an approach, such as "who will manage the charging, how to account for consumer credits or rebates for giving back energy, and any harm to batteries from the additional burden." Emily C. Dooley, *Sunny California Imagines Its Electric Cars as Mobile Power Grid*, BLOOMBERG (Jan. 10, 2020), https://news.bloombergenvironment.com/environment-and-energy/sunny-california-imagines-its-electric-cars-as-mobile-power-grid.
[80] *See* Mulkern, *supra* note 17.
[81] *See* Craig Lewis, *Don't minimize the resilience role of microgrids. They're key to mitigating wildfire and PSPS risk*, UTIL. DIVE (Nov. 18, 2019), https://www.utilitydive.com/news/dont-minimize-the-resilience-role-of-microgrids-theyre-key-to-mitigating/567489/; Roberts, *supra* note 76.
[82] *See* McNamara, *supra* note 2.
[83] *See* Roberts, *supra* note 76; Lewis, *supra* note 81.
[84] *See* Lewis, *supra* note 81; Roberts, *supra* note 76.
[85] *See* Roberts, *supra* note 76.
[86] *See* McNamara, *supra* note 2.
[87] Peter Asmus, *Microgrids could help California improve grid resilience in face of wildfire threat*, GREENBIZ (Oct. 17, 2019), https://www.greenbiz.com/article/microgrids-could-help-california-improve-grid-resilience-face-wildfire-threat.
[88] *See* Roberts, *supra* note 11.
[89] *See id.*; Lewis, *supra* note 81. Some communities, such as Montgomery County, Maryland, are experimenting with "energy as a service" financing models. *See* Lewis, *supra* note 81; Asmus, *supra* note 87.
[90] *See* Roberts, *supra* note 11.
[91] *See* Asmus, *supra* note 87.
[92] *See id.*
[93] *See* Lewis, *supra* note 81.

[94] S.B. 1339, Ch. 566, 2018–19 Leg. Sess. (Cal. 2018). The bill also "creates new financial incentives for installing them in high wildfire threat areas." Colvin, *supra* note 16.
[95] Tara Kaushik & Kevin Ashe, *Calif. Utility Commission Push Is Good News For Microgrids*, LAW360 (Mar. 4, 2020), https://www.law360.com/articles/1249372/calif-utility-commission-push-is-good-news-for-microgrids.
[96] Mark Chediak, *PG&E Inks Deal for More than 420 Megawatts of Battery Storage*, BLOOMBERG (May 19, 2020), https://news.bloomberglaw.com/environment-and-energy/pg-e-inks-deals-for-more-than-420-megawatts-of-battery-storage.
[97] S.B. 1215, 2019–20 Leg. Sess. (Cal. 2020).
[98] *See* Roberts, *supra* note 76.
[99] *See* Mulkern, *supra* note 17.
[100] *See id.*
[101] CAL. ENERGY COMM'N, *Tracking Progress – Energy Equity Indicators* 10–13 (June 25, 2018), https://www.energy.ca.gov/sites/default/files/2019-12/energy_equity_indicators_ada.pdf.
[102] Eric Daniel Fournier et al., *On energy sufficiency and the need for new policies to combat growing inequities in the residential energy sector*, ELEMENTA SCI. ANTH. 6 (2020).
[103] Emily C. Dooley, *LA's New Air Pollution Concern: Diesel Generators During Outages*, BLOOMBERG (June 19, 2020), https://news.bloomberglaw.com/environment-and-energy/las-new-air-pollution-concern-diesel-generators-during-outages.
[104] *See* Roberts, *supra* note 76.
[105] Laura Mahoney, *California Wildfires Spark Lawmakers' Tax Break Ideas*, BLOOMBERG (Mar. 6, 2020), https://news.bloombergtax.com/daily-tax-report-state/california-wildfires-spark-lawmakers-tax-break-ideas.
[106] CAL. PUB. UTIL. COMM'N, *Rules for the California Solar Initiative, the Self-Generation Incentive Program and Other Distributed Generation Issues*, Rulemaking 12-11-005 (Jan. 16, 2020); *see also* Jeff St. John, *California Seeks to Shift Major Battery Incentive Toward Fire, Blackout Resiliency*, GREENTECH MEDIA (Dec. 12, 2019), https://www.greentechmedia.com/articles/read/california-seeks-to-shift-major-battery-incentive-program-toward-fire-black.
[107] The CPUC has never spent its full Self-Generation Incentive Program (SGIP) equity budget because despite the incentives, solar plus storage systems remain too expensive for most of the target population. *See* St. John, *supra* note 106. This proposal would increase that incentive, although it would decrease funding for other SGIP priorities like "general market large-scale storage systems." *Id.*
[108] Proceeds to California from such auctions decreased from over $612 million in the first quarter of 2020 to less than $25 million in the second quarter. *See California Cap-and-Trade Program: Summary of Proceeds to California and Consigning Entities*, CAL. AIR RES. BD. (June 2020), https://ww3.arb.ca.gov/cc/capandtrade/auction/proceeds_summary.pdf.
[109] Kavya Balaraman, *Shrinking fossil fuel demand could hit California's cap-and-trade auction, experts say*, UTIL. DIVE (May 18, 2020), https://www.utilitydive.com/news/shrinking-fossil-fuel-demand-could-hit-californias-cap-and-trade-auction/578090/.
[110] *See* Roberts, *supra* note 11.
[111] *See id.*
[112] *See, e.g.*, Roberts, *supra* note 11; Murray, *supra* note 20.
[113] Mulkern, *supra* note 17.
[114] *See* Roberts, *supra* note 11 (explaining that "[t]he centrifugal force pushing people out of cities must be reversed by both widespread upzoning and aggressive social housing and homelessness policies"). However, a bill package aimed at doing this recently failed in the California state legislature. *See id.*
[115] *See id.*
[116] *See, e.g.*, Roberts, *supra* note 11.
[117] Mulkern, *supra* note 17.
[118] Cignarele et al., *supra* note 44, at 2.
[119] *Id.* at 3.
[120] *See* Roberts, *supra* note 11.
[121] *See id.*
[122] Governor Newsom's letter accompanying his veto stated that "each community is different and the best practices to achieve resiliency need to be crafted to meet the individual needs of that community." *AB 1516 Veto Message*, OFFICE OF GOVERNOR 1 (Oct. 13, 2019), https://www.gov.ca.gov/wp-content/uploads/2019/10/AB-1516-Veto-Message.pdf.
[123] *See* Colvin, *supra* note 16.

[124] Mulkern, *supra* note 17.
[125] S.B. 944, 2019—20 Leg. Sess (Cal. 2020); *see also* Mahoney, *supra* note 105.
[126] *See* PAC. GAS & ELEC. CO., *supra* note 9.
[127] Roberts, *supra* note 10.
[128] Mulkern, *supra* note 17.
[129] *See* Roberts, *supra* note 10; Mulkern, *supra* note 17; Marisa Endicott, *1,600 Cell Towers Down and At Least $50 Million Lost: California's Blackouts, by the Numbers*, MOTHER JONES (Nov. 20, 2019), https://www.motherjones.com/environment/2019/11/california-pge-fires-blackouts-statistics-hearing-state-legislature/.
[130] *See* Matthias Gafni, *PG&E shut-off: Your food is spoiled, business shut down — can you file a claim with the utility?*, S.F. CHRON. (Oct. 10, 2019), https://www.sfchronicle.com/bayarea/article/PG-E-shutoff-Your-food-is-spoiled-business-shut-14502325.php.
[131] Joaquin Palomino & Cynthia Dizikes, *Power outages hit some of the state's poorest communities hard*, S.F. CHRON. (Nov. 3, 2019), https://www.sfchronicle.com/california-wildfires/article/Power-outages-hit-some-of-state-s-poorest-14804853.php.
[132] *See* Roberts, *supra* note 10.
[133] S.B. 167, Ch. 403, 2019–20 Leg. Sess. (Cal. 2019).
[134] S.B. 560, Ch. 410, 2019–20 Leg. Sess. (Cal. 2019).
[135] *See* Cagle*, supra* note 7.
[136] Mulkern, *supra* note 17.
[137] *See id.*; McNamara, *supra* note 2.
[138] *See* PAC. GAS & ELEC. CO., *supra* note 21 at 2–3.
[139] *See id.* at 2.
[140] *See* Colvin*, supra* note 16.
[141] *See* PAC. GAS & ELEC. CO., *supra* note 21 at 5.
[142] *See* Kavya Balaraman, *PG&E is betting heavily on microgrids. But can it move away from fossil fuels?*, UTIL. DIVE (Jan. 28, 2020), https://www.utilitydive.com/news/pge-microgrid-public-safety-shutoffs-offers-distributed-energy-request-fossil-fuel-reliance/571017/. PG&E is deploying microgrids to help reach its goals of reducing the customers affected by PSPS in 2020 by one-third and restoring power twice as quickly. *Id.*
[143] *See id.* Gregory T. Bischoping, *Providing Optimal Value to Energy Consumers Through Microgrids*, 4 U. PA. J. L. & PUB. AFF. 473, 477 (2019).
[144] *See id.*
[145] Herman K. Trabish, *PG&E, SCE abandon big microgrid plans for temporary emergency measures as wildfire season nears*, UTIL. DIVE (Mar. 23, 2020), https://www.utilitydive.com/news/pge-sce-abandon-big-microgrid-plans-for-temporary-emergency-measures-as-w/574506/.
[146] PG&E was convicted in 2016 of safety violations related to a deadly gas pipeline explosion in San Bruno, California. *See* Rosenblatt et al., *supra* note 25. Because PG&E's criminal probation prohibits it from violating any laws, Judge Alsup is also closely observing the utility's role in causing subsequent wildfires. *Id.*
[147] PG&E scored itself at 60% completion for some vegetation management measures, 100% completion in wildfire safety inspection, and 114% completion for a sub-category of system hardening measures. *See id.*
[148] David R. Baker & Mark Chediak, *California's Virus War Collides With Its Other Crisis: Wildfires (1)*, BLOOMBERG (Apr. 28, 2020), https://news.bloomberglaw.com/environment-and-energy/californias-virus-war-collides-with-its-other-crisis-wildfires.
[149] J.D. Morris, *PG&E braces for a hard fire season, and blackouts, amid coronavirus pandemic*, S.F. CHRON. (June 13, 2020), https://www.sfchronicle.com/business/article/PG-E-braces-for-a-hard-fire-season-and-15337346.php?.
[150] Mark Chediak, *PG&E Planning Smaller, Shorter Power Shutoffs This Fire Season*, BLOOMBERG (June 4, 2020), https://news.bloomberglaw.com/environment-and-energy/pg-e-planning-smaller-shorter-power-shutoffs-this-fire-season.
[151] Trabish, *supra* note 145.
[152] *See* Roberts, *supra* note 11.
[153] *See* Mulkern, *supra* note 17.
[154] Trabish, *supra* note 145.
[155] *See* McNamara, *supra* note 2.
[156] *See* Cagle, *supra* note 7; Peter & Eavis, *supra* note 13.
[157] *See* Ivan Penn et al., *PG&E Reaches $13.5 Billion Deal With Wildfire Victims*, N.Y. TIMES (Dec. 6, 2019), https://www.nytimes.com/2019/12/06/business/energy-environment/pge-wildfire-victims-deal.html.

[158] *City of Oroville v. Superior Court*, 7 Cal. 5th 1091, 1102–03 (2019); *Albers v. Los Angeles Cty.*, 62 Cal. 2d 250, 262 (1965); *Holtz v. Superior Court*, 3 Cal. 3d 296, 302 (1970). Article I, section 19 of the California Constitution states that "[p]rivate property may be taken or damaged for a public use and only when just compensation . . . has first been paid to . . . the owner." CAL. CONST. art. I, § 19(a).
[159] *City of Oroville*, 7 Cal. 5th at 1102.
[160] *Holtz*, 3 Cal. 3d at 303 (citing *Bacich v. Bd. of Control*, 23 Cal. 2d 343, 350 (1943)). The idea is not that a public entity was negligent in failing to prevent harm. *Holtz*, 3 Cal. 3d at 310–11. Rather, it reflects the idea that the public entity may choose to "benefit from the cost savings from declining to pursue a reasonable maintenance program" but must pay the damages when the associated risks occur and "spread [the costs] to the community that benefits from lower costs." *City of Oroville*, 7 Cal. 5th at 1107.
[161] *Barham v. S. Cal. Edison Co.*, 74 Cal. App. 4th 744, 751 (1999).
[162] *City of Oroville*, 7 Cal. 5th at 1104.
[163] A public entity will not be held liable without a showing of fault: (1) for "damages 'inflicted in the proper exercise of police power'" or (2) when "the state at common law 'had the [r]ight to inflict the damage.'" *Holtz*, 3 Cal. 3d at 304–05 (quoting *Albers*, 62 Cal. 2d at 250, 262).
[164] A public entity can take or damage property by (1) physically invading the property in a tangible manner, (2) causing physical damage to a property without invading it, or (3) intangibly intruding on the property in a way that causes a "direct, substantial, and peculiar [burden] to the property itself." *San Diego Gas & Elec. Co. v. Superior Court*, 13 Cal. 4th 893, 940 (1996). The damage need not have been intentionally or negligently caused for inverse condemnation to apply. *See Albers*, 62 Cal. 2d at 262–64; *Holtz*, 3 Cal. 3d at 302.
[165] The damage must both be (1) the result of a risk inherent to "the deliberate design, construction, or maintenance of the public improvement" and (2) substantially caused by the improvement. *City of Oroville*, 7 Cal. 5th at 1106. While often described as proximate causation, the Supreme Court recently clarified that the inverse condemnation causation standard is different than the proximate causation analysis in tort law and is instead better described as "substantial causation." *Id.* at 1104. The inherent risk analysis considers the other underlying policy rationale of inverse condemnation by "avoid[ing] open-ended liability" for public entities. *Id.* at 1106.
[166] *See, e.g.*, *Cantu v. Pac. Gas & Elec. Co.*, 189 Cal. App. 3d 160, 165 (1987). There must be "some element of physical, but-for causation . . . present to link the public improvement and the damage," but the public improvement need not be the only cause of the damage to be liable. *City of Oroville*, 7 Cal. 5th at 1104–05, 1108. The central inquiry is whether the injury was "an 'inescapable or unavoidable consequence' of the public improvement as planned and constructed." *Id.* at 1108 (quoting Van Alstyne, *Inverse Condemnation: Unintended Physical Damage*, 20 HASTINGS L.J. 431, 437 n.32 (1969)).
[167] *See Barham*, 74 Cal. App. 4th at 753; *Pac. Bell Tel. Co. v. S. Cal. Edison Co.*, 208 Cal. App. 4th 1400, 1404–08 (2012).
[168] This is partly because the constitutional source of the inverse condemnation doctrine and related cases focus primarily on "the concept of public use, as opposed to the nature of the entity appropriating the property." *See Barham*, 74 Cal. App. 4th at 743.
[169] *San Diego Gas & Elec. Co.*, 13 Cal. 4th at 939–40.
[170] CAL. HEALTH & SAFETY CODE § 13009(a)(1) (West 1981). The costs are recoverable as a charge or debt collectible as under an express or implied contract. *Id.*
[171] *Id.* § 13007 (West 1953).
[172] *See, e.g.*, *People v. S. Cal. Edison Co.*, 56 Cal. App. 3d 593, 603–07 (1976) (affirming a judgment for the State of California to recover fire suppression costs from an electric utility under Sections 13009, 13008, and 13007 of the Health and Safety Code); *Giorgi v. Pac. Gas & Elec. Co.*, 266 Cal. App. 2d 355, 360 (affirming a judgment enabling the State to recover fire suppression costs as "its right of recovery is specifically provided for by statute" under Section 13009, but reversing in part on other grounds).
[173] *See* Jeff St. John, *California Faces Tough Choices on Utility Wildfire Liability Reform*, GREENTECH MEDIA (June 5, 2019), https://www.greentechmedia.com/articles/read/california-faces-tough-choices-on-utility-wildfire-liability-reform.
[174] *See id.* at 23.
[175] Evan Johnson et al., *Final Report of the Commission on Catastrophic Wildfire Cost and Recovery*, GOVERNOR'S OFFICE OF PLANNING & RESEARCH 6 (June 17, 2019); Ralph Cavanagh, *Potential Progress on California Wildfire Issues*, NAT'L RES. DEF. COUNCIL (May 30, 2019), https://www.nrdc.org/experts/ralph-cavanagh/potential-progress-california-wildfire-issues.
[176] *See Johnson et al., supra* note 175 at 4.

[177] According to the California Supreme Court, "there is a 'strong presumption in favor of the legislature's interpretation of a provision of the Constitution.'" *See* Cavanagh, *supra* note 175 (quoting *Property Reserve, Inc. v. Superior Court*, 1 Cal. 5th 151, 198 (2016)).
[178] *See* St. John, *supra* note 173.
[179] *See id*.
[180] *See* Ivan Penn & Peter Eavis, *California Lawmakers Give Utilities a Backstop on Wildfire Liability,* N.Y. TIMES (July 11, 2019), https://www.nytimes.com/2019/07/11/business/energy-environment/wildfire-california-utilities.html. The state legislature enacted provisions creating a Wildfire Fund "to provide funds to participating electrical corporations to satisfy eligible claims arising from [] covered wildfire[s] . . . " CAL. PUB. UTIL. CODE §§ 3284(a); 3284(c)(1) (West 2019).
[181] PUB. UTIL. CODE §§ 1701.8(a)(1), 1701.8(b)(1)(A). The electrical utility's fault is "determined by the governmental agency responsible for determining causation." *Id.* § 1701.8(a)(1). Unless it receives an exception, a utility "shall exhaust all rights to indemnification or other claims, contractual or otherwise, against any third parties" before submitting an application. *Id.* § 1701.8(b)(1)(A).
[182] *Id.* § 3291(a).
[183] *Id.* §§ 3285(a), 3285(c)(1)–(2).
[184] *Id.* §§ 3291(b)(1)(A)–(E).
[185] *Id.* §§ 3291(b)(1)(B)–(C).
[186] *See* St. John, *supra* note 173.
[187] *See* Murray, *supra* note 20.
[188] Dorothy Atkins, *PG&E Fined $3.5M For Causing 84 Deaths, Starting Camp Fire*, LAW360 (June 18, 2020), https://www.law360.com/articles/1284464/pg-e-fined-3-5m-for-causing-84-deaths-starting-camp-fire.
[189] J.D. Morris, *Regulators penalize PG&E for 2017, 2018 fires — but no $200 million fine*, S.F. CHRON. (May 7, 2020), https://www.sfchronicle.com/business/article/Regulators-penalize-PG-E-for-2017-2018-fires-15254737.php.
[190] *See* Roberts, *supra* note 11.
[191] *See id.*; Petition for Certiorari at app. 3a, *San Diego Gas & Elec. v. Pub. Util. Comm'n*, (U.S. 2019) (No. 18-1368).
[192] San Diego Gas & Elec. Co., Decision 17-11-9033 at 1 (CAL. PUB. UTIL. COMM'N Nov. 30, 2017).
[193] *See* Roberts*, supra* note 11; Petition for Certiorari at app. 4a, *San Diego Gas & Elec. v. Pub. Util. Comm'n*, (U.S. 2019) (No. 18-1368).
[194] *See San Diego Gas & Elec. v. Pub. Util. Comm'n*, Cal. S252748 (Jan. 30, 2019) (denying petition for review); *San Diego Gas & Elec. Co. v. Cal. Pub. Util. Comm'n*, 140 S. Ct. 188 (Oct. 7, 2019) (denying petition for writ of certiorari).
[195] Penn et al., *supra* note 157. The settlement will be partially paid in PG&E stock. *See* Marisa Endicott, *A Bankruptcy Judge Just Approved PG&E's $13.5 Billion Settlement With Fire Victims*, MOTHER JONES (Dec. 18, 2019), https://www.motherjones.com/politics/2019/12/bankruptcy-judge-pge-fire-victims-settlement/.
[196] However, Judge Montali clarified that his approval of the settlements did not signal that PG&E has complied with the requirements to be eligible for California's Wildfire Fund. *See* Endicott, *supra* note 195.
[197] Hannah Albarazi, *PG&E Strikes $1B Wildfire Settlement With FEMA*, LAW360 (Mar. 10, 2020), https://www.law360.com/articles/1252073/pg-e-strikes-1b-wildfire-settlement-with-fema.
[198] CAL. PUB. UTIL. COMM'N, *CPUC Staff File Proposed $1.675 Billion Settlement After Investigation of 2017-18 Catastrophic Wildfires* 1 (Dec. 17, 2019), http://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M322/K538/322538773.PDF.
[199] *See id.*
[200] Hailey Konnath, *PG&E Hit With Record $2.1B Calif. Fine Over Wildfires*, LAW360 (Feb. 27, 2020), https://www.law360.com/environmental/articles/1248424/pg-e-hit-with-record-2-1b-calif-fine-over-wildfires.
[201] Order Confirming Debtors' and Shareholder Proponents' Joint Chapter 11 Plan of Reorganization Dated June 19, 2020, *In re: PG&E Corp.*, No. 19-30088 (Bankr. N.D. Cal. June 20, 2020).
[202] Mark Chediak, *PG&E Wins Final Approval for Its Bankruptcy Reorganization (1)*, BLOOMBERG (June 20, 2020), https://news.bloomberglaw.com/bankruptcy-law/pg-e-wins-final-approval-for-its-bankruptcy-reorganization-1.
[203] J.D. Morris, *supra* note 26.
[204] Mark Chediak, *PG&E Will Replace Most of its Board After It Exits Bankruptcy*, BLOOMBERG (May 1, 2020), https://www.bloomberg.com/news/articles/2020-05-01/pg-e-will-replace-most-of-its-board-after-it-exits-bankruptcy.
[205] Mark Chediak, *PG&E Lawyer Asks for Bankruptcy Confirmation in Closing Argument*, BLOOMBERG (June 3, 2020), https://news.bloomberglaw.com/bankruptcy-law/pg-e-lawyer-asks-for-bankruptcy-confirmation-in-closing-argument.

[206] Chediak, *supra* note 202.
[207] Kavya Balaraman, *Victims blast PG&E bankruptcy plan, citing fire risk and payout concerns as approval deadline nears*, UTIL. DIVE (June 8, 2020), https://www.utilitydive.com/news/victims-blast-pge-bankruptcy-plan-citing-fire-risk-payout-and-voting-con/579337/.
[208] *PG&E Statement on Oct. 9 Public Safety Power Shutoff Customer Bill Credit*, PG&E CURRENTS (Oct. 29, 2019), https://www.pgecurrents.com/2019/10/29/pge-statement-on-oct-9-public-safety-power-shutoff-customer-bill-credit/.
[209] *See* Gafni, *supra* note 130.
[210] Governor Newsom suggested that PG&E credit residential customers $100 and business customers $250. *See* Dan Brekke, *PG&E Will Issue Customer Credits for Blackouts, Details More Damage From High Winds*, KQED NEWS (Oct. 30, 2019), https://www.kqed.org/news/11783843/pge-will-issue-customer-credits-for-blackouts-details-more-damage-from-high-winds.
[211] Memorandum Decision on Debtors' Motion to Dismiss and Strike, *Gantner v. PG&E Corp.*, No. 19-30088-DM, 2020 WL 1539254, at *1–2 (Bankr. N.D. Cal. Mar. 30, 2020).
[212] *Id.* at *4–5. Furthermore, claims based on PG&E's previous CPUC-approved actions that may have contributed to the need for PSPS "would interfere with the CPUC's policy-making decisions." *Id.* at *4. Judge Montali also noted that the causal connection between the alleged harms "and the conditions pre-dating those blackouts [wa]s top remote to defeat the [motion to dismiss], given that such PSPS events can be necessitated by high winds even when equipment is adequately maintained." *Id.*
[213] *Id.* at *3–4.
[214] S.B. 378, 2019–20 Leg. Sess. (Cal. 2020).
[215] A.B. 1915, 2019–20 Leg. Sess. (Cal. 2020).
[216] The study weighed the factors of sea level rise, extreme precipitation, extreme drought, urban heat islands, and average temperature and precipitation changes. Michele Berger, *The weather.com Climate Disruption Index: 25 U.S. Cities Most Affected by Climate Change*, WEATHER CHANNEL, http://stories.weather.com/disruptionindex (last visited June 27, 2020).
[217] Roxanne Palmer, *Why Did Hurricane Sandy Knock Out New York City's Power Grid?*, INT'L BUS. TIMES (Nov. 14, 2012), https://www.ibtimes.com/why-did-hurricane-sandy-knock-out-new-york-citys-power-grid-879440.
[218] Ian Bogost, *Revenge of the Power Grid*, ATLANTIC (July 15, 2019), https://www.theatlantic.com/technology/archive/2019/07/manhattan-blackout-reveals-infrastructure-risk/594025/.
[219] *See* Palmer, *supra* note 217; Carol J. Clouse, *5 Years After Superstorm Sandy, New York's Still Vulnerable To Widespread Power Outages*, HUFF. POST (updated Nov. 1, 2017), https://www.huffpost.com/entry/nyc-power-outages-superstorm-sandy_n_59f37004e4b07fdc5fbdf009.
[220] *See* Bogost, *supra* note 218.
[221] Alexander C. Kaufman, *Power Plant Explosion Casts New Light on New York's Addiction to Dirty Fuel*, MOTHER JONES (Dec. 28, 2018), https://www.motherjones.com/environment/2018/12/power-plant-explosion-casts-new-light-on-new-yorks-addiction-to-dirty-fuel/.
[222] James M. Van Nostrand, *Keeping the Lights on During Superstorm Sandy: Climate Change Adaptation and the Resiliency Benefits of Distributed Generation*, 23 NYU ENVTL. L.J. 92, 95 (2015).
[223] *See* Bogost, *supra* note 218; *Coronavirus Live Updates: As the epidemic in New York explodes, other states worry about domestic contagion*, N.Y. TIMES, https://www.nytimes.com/2020/03/24/world/coronavirus-updates-maps.html#link-15eb3216 (explaining that NYC "is far more crowded than any other major city in the United States") (last visited Mar. 24, 2020).
[224] *See* Clouse, *supra* note 219.
[225] *See id.*
[226] *See* Bogost, *supra* note 218.
[227] Marianne Lavelle, *Can Hurricane Sandy Shed Light on Curbing Power Outages?*, NAT'L GEOGRAPHIC NEWS (Nov. 2, 2012), https://www.nationalgeographic.com/news/energy/2012/11/121102-hurricane-sandy-power-outages/.
[228] *See* Clouse, *supra* note 219.
[229] *See* Rae Zimmerman et al., *New York City Panel on Climate Change 2019 Report Chapter 7: Resilience Strategies for Critical Infrastructures and Their Interdependencies*, ANN. N.Y. ACAD. SCI. 174, 192, 195 (March 15, 2019), https://nyaspubs.onlinelibrary.wiley.com/doi/10.1111/nyas.14010 (explaining that NYC's infrastructure "both affects and is affected by the region beyond [the] borders" of the city's 300-square-mile area).
[230] Andrew Rice, *This is New York in the not-so-distant future*, N.Y. MAG. (Sept. 5, 2016), https://nymag.com/intelligencer/2016/09/new-york-future-flooding-climate-change.html.

[231] Maria Gallucci, *N.Y. Regulator, Con Ed Embrace Plan to Climate-Proof Power Grid*, INSIDE CLIMATE NEWS (March 12, 2014), https://insideclimatenews.org/news/20140312/ny-regulator-con-ed-embrace-plan-climate-proof-power-grid.
[232] *See id.*; Rice, *supra* note 230.
[233] Van Nostrand, *supra* note 222 at 95.
[234] Zimmerman et al., *supra* note 229 at 179.
[235] *See* Rice, *supra* note 230 (explaining that "[t]he human tide is moving in the wrong direction, still marching toward the waterline").
[236] *See id.*
[237] Emily Nonko, *New York's Plans to Tackle Climate Change May Leave Some Residents Behind*, GUARDIAN (Sept. 22, 2019), https://www.scientificamerican.com/article/new-yorks-plans-to-tackle-climate-change-may-leave-some-residents-behind/.
[238] *See* Rice, *supra* note 230.
[239] *See* Nonko, *supra* note 237.
[240] *See* Temming, *supra* note 1.
[241] Stephen Lacey, *Resiliency: How Superstorm Sandy Changed America's Grid*, GREENTECH MEDIA (June 10, 2014), https://www.greentechmedia.com/articles/featured/resiliency-how-superstorm-sandy-changed-americas-grid (describing the United States' "long-term trend of increase in power outages due to extreme weather since the 1980s").
[242] *See* Bryan Walsh, *Hurricane Sandy Will Put a Rickety Power Grid to the Test*, TIME MAG. (Oct. 30, 2012), https://science.time.com/2012/10/30/hurricane-sandy-will-put-a-rickety-power-grid-to-the-test/.
[243] *See* Van Nostrand, *supra* note 222 at 92; Lavelle, *supra* note 227 (calling the storm "proof of the need for massive investment to make the electric power grid more resilient").
[244] *See* Lacey; *supra* note 241.
[245] *See* Van Nostrand, *supra* note 222 at 92.
[246] *See* Lacey, *supra* note 241; Clouse, *supra* note 219 (describing Sandy as "the worst storm in U.S. history in terms of outages (until Hurricane Maria hit Puerto Rico [in 2017])").
[247] Van Nostrand, *supra* note 222 at 102.
[248] This represented 90% of LIPA's customers. *Id.* at 102.
[249] *See* Gallucci, *supra* note 231.
[250] *See* David Rohde, *The Hideous Inequality Exposed by Hurricane Sandy*, ATLANTIC (Oct. 31, 2012), https://www.theatlantic.com/business/archive/2012/10/the-hideous-inequality-exposed-by-hurricane-sandy/264337/.
[251] Daniel Aldana Cohen & Max Liboiron, *New York's Two Sandys*, METRO POLITICS (Oct. 30, 2014), https://www.metropolitiques.eu/New-York-s-Two-Sandys.html.
[252] *See* Walsh, *supra* note 242; Palmer, *supra* note 217; Van Nostrand, *supra* note 222 at 101.
[253] *See* Walsh, *supra* note 242; Clouse, *supra* note 219; Lavelle, *supra* note 227.
[254] *See* Lavelle, *supra* note 227; Van Nostrand, *supra* note 222 at 101.
[255] *See* Bogost, *supra* note 218.
[256] *See* Zimmerman et al., *supra* note 229 at 189.
[257] *See* Bogost, *supra* note 218.
[258] Van Nostrand, *supra* note 222 at 102.
[259] *Id.*
[260] *See* Palmer, *supra* note 217.
[261] Van Nostrand, *supra* note 222 at 102.
[262] Diane Cardwell et al., *Hurricane Sandy Alters Utilities' Calculus on Upgrades*, N.Y. TIMES (Dec. 28, 2012), https://www.nytimes.com/2012/12/29/business/hurricane-sandy-alters-utilities-calculus-on-upgrades.html. Superstorm Sandy was "the worst natural disaster in Con Ed[]'s history." Van Nostrand, *supra* note 7 at 101.
[263] Van Nostrand, *supra* note 222 at 102.
[264] *Id.* at 102–03.
[265] Walsh, *supra* note 242; Zimmerman et al., *supra* note 229 at 179.
[266] *See* Lavelle, *supra* note 227; Zimmerman et al., *supra* note 229 at 179.
[267] *See* Walsh, *supra* note 242; Lavelle, *supra* note 227 (explaining that fortunately none of the thirty-four nuclear plants within Superstorm Sandy's path experienced meltdowns, unlike the Fukushima disaster in Japan).
[268] Zimmerman et al., *supra* note 229 at 179.
[269] *See* Palmer, *supra* note 217.
[270] *See* Nonko, *supra* note 237.

[271] *See id.* ("During Sandy, flooding from both waterfronts—one lined with a defunct landfill, the other a city-owned wasteland—debilitated the neighborhood").
[272] Walsh, *supra* note 242.
[273] Zimmerman et al., *supra* note 229 at 179.
[274] *See* Palmer, *supra* note 217.
[275] *See* Clouse, *supra* note 219.
[276] Gallucci, *supra* note 231.
[277] Bogost, *supra* note 218; Temming, *supra* note 1; Zimmerman et al., *supra* note 229 at 179.
[278] Gallucci, *supra* note 231.
[279] Bogost, *supra* note 218.
[280] *See id.*; Zimmerman et al., *supra* note 229 at 179 (explaining that heat waves might lead to an increase in energy demand and consumption, including "extreme energy use" days, and strain grid capacity).
[281] Gallucci, *supra* note 231.
[282] Zimmerman et al., *supra* note 229 at 179.
[283] *See* Temming, *supra* note 1.
[284] Clouse, *supra* note 219; Bogost, *supra* note 218; Gallucci, *supra* note 231.
[285] Bogost; *supra* note 218 (explaining that heat waves "increase[] electrical load, which puts greater pressure on infrastructure").
[286] Meg Anderson & Sean McMinn, *As Rising Heat Bakes U.S. Cities, The Poor Often Feel It Most*, NAT'L PUB. RADIO (Sept. 3, 2019), https://www.npr.org/2019/09/03/754044732/as-rising-heat-bakes-u-s-cities-the-poor-often-feel-it-most.
[287] Zimmerman et al., *supra* note 229 at 179.
[288] *Id.*
[289] New York State Climate Leadership & Community Protection Act, S.B. S6599, 2019–2020 Leg. Sess. (N.Y. 2019).
[290] *See* Robert Verchick, *Our Energy Grid is Incredibly Vulnerable*, SLATE (Aug. 26, 2016), https://slate.com/technology/2016/08/our-energy-grid-is-incredibly-vulnerable-to-climate-change.html.
[291] Cardwell et al., *supra* note 262.
[292] *See id.*
[293] Con Ed estimated that recovering the cost of this one grid hardening measure would require tripling electricity rates for a decade. *See id.*
[294] *See* Verchick, *supra* note 290.
[295] *See* Van Nostrand, *supra* note 222 at 104.
[296] *See* Meredith Hiller & Stephen J. Humes, *Resilience in the Utility Industry: Working Against the Rising Tides*, 31 NAT. RES. & ENV'T 12, 13 (2017).
[297] *See* Zimmerman et al., *supra* note 229 at 202; Van Nostrand, *supra* note 222 at 108–09. This 14.4-megawatt combined heat and power (CHP) system provides power to twenty-two buildings and thermal energy to thirty-seven buildings on campus. Van Nostrand, *supra* note 222 at 108–09.
[298] *See* Zimmerman et al., *supra* note 229 at 202; Van Nostrand, *supra* note 222 at 110–11; Kevin B. Jones et al., *The Urban Microgrid: Smart Legal and Regulatory Policies to Support Electric Grid Resiliency and Climate Mitigation*, 41 FORDHAM URBAN L.J. 1695, 1724 (2014). Co-Op City relies on a forty-megawatt natural gas-powered CHP facility to meet almost all of its electrical and thermal needs. Van Nostrand, *supra* note 222 at 110–11.
[299] *See* Van Nostrand, *supra* note 222 at 110; Bischoping, *supra* note 143, at 479.
[300] This fifty-seven-megawatt CHP system also enabled Nassau Community College to create an emergency shelter that served more than one thousand people for up to a month and a half. Van Nostrand, *supra* note 222 at 111.
[301] Applicants were encouraged to identify critical facilities their proposed microgrids would support, including hospitals, wastewater treatment plants, communications infrastructure, fire stations, police stations, emergency shelters, and schools. *See* Justin Gundlach, *Microgrids and Resilience to Climate-Driven Impacts on Public Health*, 18 HOUSTON J. HEALTH L. & POLICY 77, 127–28 (2018); Jones, *supra* note 298 at 1727–28.
[302] *See* Gundlach, *supra* note 301 at 127–28.
[303] *See* Zimmerman et al., *supra* note 229 at 200.
[304] *See* Van Nostrand, *supra* note 222 at 118–19; Bobby Magill, *Microgrids: Sandy Forced Cities to Rethink Power Supply*, CLIMATE CENTRAL (Sept. 9, 2013), https://www.climatecentral.org/news/microgrids-hurricane-sandy-forced-cities-to-rethink-power-supply-16426; Jones, *supra* note 298 at 1733; Bischoping, *supra* note 143, at 479.
[305] *See* Magill, *supra* note 304; Jones, *supra* note 298 at 1729–30, 1735.

[306] *See* Van Nostrand, *supra* note 222 at 153–54; Bischoping, *supra* note 143, at 487.
[307] *See* Van Nostrand, *supra* note 222 at 118–19; Bischoping, *supra* note 143, at 477, 479–80.
[308] *See* Jones, *supra* note 298 at 1739–40; Bischoping, *supra* note 143, at 479–80.
[309] *See* Sunter, *supra* note 75.
[310] *See, e.g.*, *Equity and Justice: Bending the Arc of the Technology Curve Toward Vulnerable Populations*, CLEAN ENERGY GRP., https://www.cleanegroup.org/ceg-projects/energy-storage/equity-and-justice/ (last visited Apr. 10, 2020) (explaining that microgrids are usually adopted by wealthier communities first and that "[v]ery few of these projects are in disadvantaged communities" despite the fact that "low-income customers need the benefits of solar and battery storage systems the most").
[311] *See* Zimmerman et al., *supra* note 229 at 200.
[312] *See* Peter Maloney, *Who Pays on a Decentralized Grid? New York tackles the Equity Problem with New Rates*, MICROGRID KNOWLEDGE (May 28, 2019), https://microgridknowledge.com/standby-and-buyback-rates-new-york/ (explaining that the PSC "revamped utility standby and buyback rates" in an effort to address these issues).
[313] *See* Verchick, *supra* note 290.
[314] *See* Van Nostrand, *supra* note 222 at 120.
[315] *See* Gwynne Hogan, *'They Dragged Their Feet': Con Ed's Plan For Heat Waves Is Years Behind Schedule*, GOTHAMIST (July 24, 2019), https://gothamist.com/news/they-dragged-their-feet-con-eds-plan-for-heat-waves-is-years-behind-schedule.
[316] *See* Jennifer Runyon, *Con Edison will reduce peak demand with NYC's largest battery storage system*, RENEWABLE ENERGY WORLD (Dec. 10, 2019), https://www.renewableenergyworld.com/2019/12/10/con-edison-will-reduce-peak-demand-with-nycs-largest-battery-storage-system/#gref.
[317] *See, e.g.*, Gundlach, *supra* note 301 at 125; Verchick, *supra* note 290 (explaining that "the problem . . . isn't a lack of smart technology; it's a lack of smart policy").
[318] *See* Zimmerman et al., *supra* note 229 at 202.
[319] *See id.* at 202–03.
[320] *See id.* at 205.
[321] *See id.* at 202.
[322] *See* Hiller & Humes, *supra* note 296 at 14.
[323] *See* Van Nostrand, *supra* note 222 at 118.
[324] *See* Bischoping, *supra* note 143, at 480.
[325] *See id.* at 487.
[326] *See* Van Nostrand, *supra* note 222; Marianne Lavelle, *supra* note 227.
[327] *See* Jonathan Schneider & Jonathan Trotta, *What We Talk About When We Talk About Resilience*, 39 ENERGY L.J. 353, 373 (2018) (describing New York as "among the more active states" in terms of resilience, "with activity that began soon after Hurricane Sandy"); Gavin Bade, *Beyond the substation: How 5 proactive states are transforming the grid edge*, UTIL. DIVE (March 2, 2015), https://www.utilitydive.com/news/beyond-the-substation-how-5-proactive-states-are-transforming-the-grid-edg/369810/ (calling New York one of "the five states . . . doing the most to push their utilities toward the business models of the future").
[328] *See* Bade, *supra* note 327 (explaining that New York is among the states "most proactively looking at regulatory changes that would facilitate . . . transformations" toward grid resilience).
[329] New York State Climate Leadership & Community Protection Act, S.B. S6599, 2019–2020 Leg. Sess. (N.Y. 2019). *See also* Michelle Froese, *New York launches renewables & electric grid modernization challenge*, WIND POWER ENG'G (July 12, 2019), https://www.windpowerengineering.com/new-york-launches-renewables-electric-grid-modernization-challenge/; Robert Walton, *New York passes 100% clean energy bill, but advocate calls it a 'partial victory'*, UTIL. DIVE (updated June 20, 2019), https://www.utilitydive.com/news/ny-poised-to-pass-100-clean-energy-bill-but-advocate-calls-it-a-partial/557164/.
[330] *Id.*
[331] It specifies goals for projects to help particular utilities, including proposals to help Consolidated Edison, Inc. (Con Ed) advance its distributed energy implementation and management. *See* Froese, *supra* note 329.
[332] *See* Bade, *supra* note 327.
[333] *See id.*
[334] Hiller & Humes, *supra* note 296 at 14.
[335] Ethan Howland, *NYISO expects to add carbon pricing in 2022*, CQ ROLL CALL (May 11, 2018).
[336] *See* Zimmerman et al., *supra* note 229 at 199.
[337] *See* Jones, *supra* note 298 at 1733.
[338] *See id.*

[339] *See* Van Nostrand, *supra* note 222 at 117.
[340] *See* Jones, *supra* note 298 at 1733.
[341] *See* Van Nostrand, *supra* note 222 at 116, 103. The proposed grid hardening measures included "strategic undergrounding and flood protection," such as elevating critical equipment and building flood walls. *Id.* at 104.
[342] *See id* at 115–17 (the organizations included Environmental Defense Fund, Natural Resources Defense Council, Pace Energy and Climate Center, and Columbia Law School's Sabin Center for Climate Change Law).
[343] *See id.* at 124–25.
[344] At the PSC's request, Con Ed and the other stakeholders formed a Storm Hardening and Resiliency Collaborative to consider climate impacts on the utility's infrastructure and help guide its grid hardening efforts. *See id.*
[345] Measures include replacing vulnerable equipment, elevating critical infrastructure, and installing flood control pumps and backup generators. *See* Jenna Schweitzer, *ConEd Invests $1 Billion in Infrastructure Resilient to Climate Change*, REG. REV. (March 25, 2014), https://www.theregreview.org/2014/03/25/25-shweitzer-infrastructure/.
[346] *See* Hiller & Humes, *supra* note 296 at 13. In 2016, the PSC approved another $459 million request by Con Ed for grid hardening and resiliency measures. *See id.* Kavya Balaraman, *PG&E is betting heavily on microgrids. But can it move away from fossil fuels?*, UTIL. DIVE (Jan. 28, 2020), https://www.utilitydive.com/news/pge-microgrid-public-safety-shutoffs-offers-distributed-energy-request-fossil-fuel-reliance/571017/.
[347] *See* Emma Foehringer Merchant, *What Superstorm Sandy Taught Consolidated Edison, 5 Years On*, GREENTECH MEDIA (Oct. 27, 2017), https://www.greentechmedia.com/articles/read/what-superstorm-sandy-taught-consolidated-edison.
[348] *See id.*
[349] *See* Gwynne Hogan, *supra* note 315.
[350] *See id.*