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Key Considerations for Electric Sector Climate Resilience Policy and Investments

Executive Summary

The increasing threats of climate change are requiring utilities to make operational changes and investments to improve the resilience of the electric system. This report identifies ways in which both utility regulators and other state and local policymakers can support and guide utility resilience planning, exploring key elements that must be considered when developing electric utility resilience planning. It also includes case study examples to further highlight possible opportunities in the planning process and benefits of proactive resilience planning and investments.

Utility regulators must make a series of decisions to ensure that utilities are able to provide safe, reliable, resilient, environmentally responsible, and affordable service to their customers. By ensuring just and reasonable rates, serving as a nexus for resilience standards, and assessing and approving utility investments, these regulators play numerous important roles in guiding utility investment in improving resilience. Each state faces a unique set of conditions and requirements for resilience, ranging from the changing climate impacts the region faces, to the policies and goals of the state, to the technological conditions and state of the grid and local businesses. Each utility regulator will, therefore, approach climate resilience investments and actions differently. Key considerations include:

- Resilience strategy development for utilities: utility regulators should ensure they and utilities consider potential impacts on resilience as a key factor in utility investments and encourage the development of proactive resilience strategies that can help optimize and coordinate resilience investments.
- Forward-looking cost benefit analysis and consideration of state-specific climate risks: electric sector investments will need to consider/reflect a range of future conditions—with a design standard that is appropriate for deterioration in conditions due to climate change. Utility regulators must update assessment of such investments to ensure a sufficient level of preparation for future conditions, including a more comprehensive view of resilience services of a range of potential resources.

Definition of Climate Resilience

There are many ways to define "resilience," and many different risks and challenges through which a utility system must be resilient. In this report, we are focused on those physical risks that are associated with climate change. Therefore, for the purposes of this report, we have defined climate resilience as:

> **the ability of the electric power generation and delivery system to withstand and recover from disruptive events and to anticipate, adapt, and continue to reliably serve customers in the face of a changing climate and associated risks.**

- Situation-specific and responsive resilience metrics and goals: utility regulators must help to define and develop a set of metrics to quantify resilience that are specific to the needs of local electric utilities and grid operators and responsive to changes in grid operations and climate change conditions.
- Data collection and dynamic assessment: data collection and dynamic assessment of system performance are critical to ensure that infrastructure upgrades are optimized to respond to the events or conditions with the largest impacts—and that these investments are providing the desired improved resilience. Utilities and utility regulators should regularly assess available information for gaps and new questions and use collected system data to frame ongoing infrastructure spending.

Utilities also operate within the context of their state and local policy contexts. Myriad agencies, including Departments of Environment, Energy, or Planning as well as Governors and Mayors offices and city councils and state legislatures often create policy mandates that drive utility action. All of these policymakers are part of the resilience ecosystem in which utilities plan, operate, and respond to disasters and other climate conditions. Policymakers set overarching climate and resilience goals or planning processes, can help guide utility resilience investments in a way that both reinforces and draws upon broader resilience efforts, and serve as an important source, and distributor, of climate resilience funding. Policymakers may want to consider the following key factors to support utility resilience action:

- State or local targets for resilience and climate adaptation: state and local resilience and adaption plans provide a different and important view on resilience that can be paired with utility-specific resilience strategies. Additionally, such local and state plans can be an important catalyst for utility and utility regulatory action by laying out high level goals, desired utility performance or actions, or descriptions of critical services.
- Localized data and resources: local and state policymakers can be an important conduit for climate adaptation research and resources, including downscaled climate science and modeling, local projections of impacts on communities, businesses, and infrastructure, and creating and maintaining dashboards or other collections of programs, plans, and funding opportunities.
- Resilience action coordination: utility resilience strategies must be coordinated with these and other stakeholders. State and local policymakers can create forums for sharing information, exchanging best practices, and creating accountability across parties.
- Funding opportunities to support or complement utility resources: as community climate resilience needs grow, there may sources of funding that can complement utility-sourced funding and help to ensure that proactive and comprehensive investments can be made across communities. States and local governments can direct and manage these funding sources in line with local targets and other considerations.

Climate Resilience: Importance and Foundations

The past several years have provided concrete and real examples for federal, state, and local policymakers of the impacts that climate change will have on their communities. From the catastrophic 2018 fire season in California to the 2019 flooding in the Midwest to the series of damaging hurricane seasons in the Southeast, the United States is already experiencing increasing disasters and conditions consistent with climate change. According to 2018 reports by both the Intergovernmental Panel on Climate Change (IPCC) and the National Climate Assessment (NCA), these effects will only continue to grow, damaging critical infrastructure and impacting human health and wellbeing.[1] As temperatures rise, regions will begin to feel these effects at different scales over time. For example, while both East and West coast communities are expected to receive increased storm water inundation and sea level rise, the West coast is anticipated to receive less rain fall and the East coast is expected to see the frequency and intensity of downpours to increase.[2]

These changing conditions will require communities to adapt in many respects—and many of these impacts will affect the electric sector. As the climate warms, areas will experience both increase heating degree days and cooling degree days, which will impact electric grid requirements. The grid will also face the impact of climate change directly in the form of flooding, ice storms, fire, and sea level rise.[3] In the Northeast for example, the NCA found that flooding from heavy rainfall, storm surge, and rising high tides will compound existing issues with aging infrastructure and further found that critical infrastructure such as water facilities, transportation centers, and telecommunication systems, are already at risk during a category two hurricane.[4] Electric utilities are also facing increased demands for resilience in addition to reliability to ensure that an increasingly electrified country can withstand climate storms and conditions. In order to prepare for climate change, electric utilities must incorporate resilience planning into their long-term planning processes. Utilities have a range of resources available to them in improving and incorporating climate resilience into their operations, starting with a suite of resources at the federal level. The realities of climate change have caused the federal government, states, electric utility regulators, and electric utilities to begin to evaluate ways to reduce and mitigate these risks through resilience planning. The federal government has had a wide variety of agency initiatives and executive orders that have addressed climate resilience, including many focused on modeling and data collection for communities. Several of Department of Energy (DOE) initiatives focused specifically on the electric sector, including the Partnership for Energy Sector Climate Resilience, the State and Local Energy Assurance Planning, among others.[5] While many of these initiatives are less prominent in the current Administration, several efforts remain ongoing.

Notably, in the past years, the Federal Energy Regulatory Commission (FERC) and DOE issued requests for information to gather additional information on ways to define, develop, and incentivize electric utility resilience planning. Specifically, the FERC inquiry included questions on whether resilience should be incentivized by FERC based upon its reliability-enhancing attributes. DOE's request for information (RFI) focused on state and industry best practices around generation, transmission, control centers, and distribution facility resilience against severe weather events to possibly aid Federal Emergency Management Authority (FEMA) in implementing the Disaster Recovery Reform Act of 2018. While these proposals are currently being developed and discussed, both demonstrate an ongoing interest in electric utility resilience planning at the federal level. However, the NCA

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1 USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, et al. (eds.)]

2 Walsh, J., D. Wuebbles, K. Hayhoe, et al., 2014: Ch. 2: Our Changing Climate. Climate Change Impacts in the United States: The Third National Climate Assessment, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 19-67. doi:10.7930/J0KW5CXT. p. 20.

3 Maxwell, K., S. Julius, A. Grambsch, et al., 2018: Built Environment, Urban Systems, and Cities. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, et al. (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 438–478. doi: 10.7930/NCA4.2018.CH11

4 Dupigny-Giroux, L.A., E.L. Mecray, M.D. Lemcke-Stampone, et al., 2018: Northeast. In Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, et al. (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, pp. 669–742. doi: 10.7930/NCA4.2018.CH18

5 For more information on all federal climate resilience initiatives, see MJB&A's Issue Brief, *Key Federal Activities Related to Climate Resilience.*

notes, "while migration and adaptation efforts have expanded substantially in the last four years, they do not yet approach the scale considered necessary to avoid substantial damages to the economy, environment, and human health over the coming decades."[6]

It is here where states, local governments, and utilities are stepping up to take these national resources and apply them to their local conditions. For electric utilities, each utility will face differing risks and impacts of climate, and each will approach climate resilience planning and investment differently. There are many ways that electric utilities can begin to increase resilience both within their own systems and for their communities. From collecting data on existing infrastructure to investing in storm hardening infrastructure and long-term climate modeling, electric utilities can begin to develop dynamic resilience plans in collaboration with their service territory communities. Building off of federal resources and translating them to the local level, state and local governments and regulators also have role in assisting utilities in these planning processes.

Utilities will face challenges in increasing the resilience of the system. First, while climate modeling only continues to become more robust, there are inherent uncertainties regarding the intensities and timing of climate change. It will be impossible for utilities to plan for every foreseeable outcome from climate change and investment and infrastructure planning will likely need to develop and grow overtime. Second, as climate changes and new technologies are developed, design standards will likely develop to incorporate better system understanding. This may mean that some infrastructure investments today will not meet the design standards of tomorrow. This leads to a final, and key, component that must be considered when developing and implementing resilience planning processes—balancing rate impacts. Utilities must increase investment in grid infrastructure to avoid more costly system repairs and outages in the future; waiting until systems are failing to perform reliably and resiliently under climate change will be far more expensive than proactive investment now. However , it is also important to consider the cost that will be felt by ratepayers, especially low-to-moderate income populations many of whom may already pay an electricity bill that makes up a large percentage of their income. Resilience planning processes must be mindful of these communities and ratepayers when implementing their plan.

This report identifies ways in which both utility regulators and other state and local policymakers can support and guide utility resilience planning to help overcome these challenges. The report also explores key elements that must be considered when developing electric utility resilience planning. It also includes case study examples to further highlight possible opportunities in the planning process and benefits of proactive resilience planning and investments.

Climate Resilience and Utility Regulators

Utilities are subject to many levels of regulation. In every state, governing bodies, often called public utilities commissions or public service commissions, regulate the service and rates of investor owned electric utilities. These regulators must balance a series of factors to ensure that utility service meets state goals and customer interest. Publicly owned and municipal utilities are subject to a similar set of regulatory oversight from their boards and municipal governments.

Key Utility Regulator Roles

Each of these bodies, for the purpose of this report called "utility regulators," play numerous important roles in guiding utility investment in improving resilience. The lodestar for utility regulators is to ensure just and reasonable rates for utility customers. In addition, these regulators must make a series of decisions, explored in

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6 USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, et al. (eds.)]

more detail below, to ensure that utilities are able to provide safe, reliable, resilient, environmentally responsible, and affordable service to their customers. In the context of resilience investments and planning, this will involve three primary factors described below.

First, utility regulators must determine how "reasonable" rates balance both short term and long-term costs. A policy that minimizes short term spending in order to lower rates (or avoid rate increases) could mean a system that is ill-prepared for severe events and future conditions—leading to more frequent or lengthy outages. Estimates of average annual economic costs of power outages over the last decades due to severe weather alone range from $20 to $30 billion, with some single events causing damages of up to $75 billion. This can include preemptive outages that are intended to reduce climate disaster risk, but nevertheless lead to significant customer impacts. For example, California utilities have seen the economic and safety impact of preemptive power shut offs rise to $1 billion or more.[7] Regulators must carefully compare the costs of a lack of resilience against those of investments to improve resilience when considering impacts on customers and customer rates.[8]

Second, utility regulators are at a critical nexus of policymaking when it comes to resilience standards and processes. There are multiple parties involved in this process. At the federal level, the North American Electric Reliability Corporation (NERC) sets standards and enforces system reliability for the bulk power grid (in conjunction with regional grid operators, as appropriate). FERC sets broad policy around resource development that can affect reliability and resiliency and plays a central role in approving many transmission projects, another factor in considering regional resilience. FEMA sets emergency response standards and is at the forefront of recovery efforts and funding. At the same time, states and local governments are also setting local requirements for climate preparedness, adaptation, and resilience—and utilities are central to these plans. Utility regulators, however, are in a unique position to provide integration, guidance, and oversight on implementation given as these regulators are arguably the closest to utility activity and can consider the specific factors relevant to each utility's unique service area.

Finally, utility regulators are critical in assessing and approving utility resilience investment plans, including over long-term planning horizons. As highlighted above, these plans must be reasonable from a cost perspective but must also be in compliance and alignment with resilience standards and climate adaptation plans. In addition to balancing these important priorities, utility regulators can add the important perspective to determine the appropriate timing and considerations for investments to ensure both proactive action and a recognition of ongoing changing conditions and uncertainty.

Key Utility Regulator Considerations

Each state faces a unique set of conditions and requirements for resilience, ranging from the changing climate impacts the region faces, to the policies and goals of the state, to the technological conditions and state of the grid and local businesses. Each utility regulator will, therefore, approach climate resilience investments differently. Some of these key considerations are highlighted in this section.

Resilience strategy development for utilities

Utilities are making constant updates to their systems to better serve customers and to meet federal, state, and local policy requirements. Utility regulators should ensure that impacts on resilience are considered as a key

7 San Francisco Chronicle, *'A cool billion': Economists estimate PG&E outages could have big impact*, October 9, 2019.

8 *Economic Benefits of Increasing Electric Grid Resilience to Weather Outages*, Executive Office of the President, August 2013, https://www.energy.gov/downloads/economic-benefits-increasing-electric-grid-resilience-weather-outages

factor in these investments and encourage the development of proactive resilience strategies that can help optimize and coordinate resilience investments.

Many states have specific climate resilience goals or targets that require utilities to increase the resilience of their systems. For example, in 2018, Governor Cooper of North Carolina signed Executive Order 80, which calls for action to prepare for the impacts of climate change (adaptation and resilience) and for mitigation efforts. As a result of the Order, the state is required to, among other things, integrate climate adaptation and resiliency goals into agency programs, policies, and operations and develop a "North Carolina Climate Risk Assessment and Resiliency Plan" by March 1, 2020.[9] Resilient electric systems will be critical for meeting nearly all components of these plans, as communities are dependent on electric service and hospitals, businesses, and emergency responders and others require consistent electric service to meet their own resilience obligations.

States also have climate mitigation goals that require significant action by utilities. Mitigation plans may require certain clean energy procurement targets or emissions reductions or may call for specific investments in emerging technologies. For example, 29 states have renewable procurement targets, and 15 states have policies to encourage or reduce the barriers to energy storage.[10] In many cases, these investments can serve double duty, both reducing greenhouse gas emissions and providing critical elements of a resilience grid by improving local service or helping to create microgrids. In these cases, utility regulators will need to take into account how certain investments can be optimized to target both mitigation and adaptation.

Utility regulators can help to implement these state goals and translate them to the utility sector through a range of mechanisms. Dedicated climate resilience proceedings, such as those undertaken in California, can help to create a broad view of a resilience strategy that takes into account mitigation activities and other utility investments. A resilience lens for existing proceedings or commission activities, such as procurement approval or rate cases, could also be appropriate for other states. For example, utility regulators could require that every major investment include a consideration of how that investment takes into account applicable strategies and local projected conditions as they change due to climate change impacts. Absent existing state action or directives, utilities can also independently submit requests and bring them to utility regulators for approval for strategic investments to meet ongoing state and local requirements.

Case Study: Eversource Climate Mitigation and Resilience Strategy

In 2017, the Massachusetts DPU issued an order requiring Eversource to pursue investments in advanced technologies in an effort to strengthen the state's clean energy economy and reduce greenhouse gas emissions including ways to improve resilience throughout their service territory.

As part of its petition, Eversource highlighted the need for increased spending around "system reliability improvements, system resiliency improvements to address the effects of climate change, distribution system changes to allow for two-way power flows, and cyber security needs and mitigation of environmental impacts related to distribution

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[9] *Climate Risk Assessment and Resiliency Plan*, North Carolina Department of Environmental Quality. https://deq.nc.gov/energy-climate/climate-change/nc-climate-change-interagency-council/climate-change-clean-energy-0

[10] *Update on State Clean Energy Policies*, M.J. Bradley and Associates, July 3, 2019. https://mjbradley.com/reports/update-state-clean-energy-policies

infrastructure" amidst declining sales.[11] The DPU explained that it approved Eversource's performance based rate (PBR) in part because it, "address(ed) lost sales growth and allow(ed) Eversource to best meet its public service obligations in terms of providing safe, reliable, least-cost service to customers and ensure(ed) that the Commonwealth's clean energy goals are met."[12]

The DPU approved this PBR in part because it incentivized Eversource to be efficient and innovative in resilience planning and clean energy development instead of incentivizing the utility to focus on specific capital investments without looking for broader systemwide opportunities like a capital cost recovery mechanism might incentivize.[13] There are several innovative components to this PBR that make it particularly well designed to encourage future resilience planning. One such component is the negative productivity offset factor. At the time, the DPU stated that no other utility had ever proposed—and received approval for—a negative productivity offset factor. The DPU approved this offset factor because it recognized that the utility will likely need to invest more in its assets than it will receive in customer sales based on future changes to the utility's service territory due to climate change.[14] Eversource also designed the PBR to operate in a five year term to enable increased long-term planning. The DPU supported this goal in their approval stating, "a well-designed PBR should be of sufficient duration to give the plan enough time to achieve its goals and to provide utilities with the appropriate economic incentives and certainty to follow through with medium and long term strategic business decisions."[15] The DPU further directed Eversource to conduct its own climate adaptation study to identify areas that are most vulnerable to climate change and could jeopardize system reliability.[16]

As part of this petition, the DPU also approved a vegetation management resiliency pilot and directed Eversource to track and maintain necessary information related to its enhanced vegetation management initiative, including costs, benefits, and its contribution to reliability improvements. Eversource explained that its system infrastructure is vulnerable to ice storms, heavy wet snow, tropical storms, hurricanes and other wind events that cause substantial damage and prolonged power outages and asserted that without a resilient grid, real-time sensing and monitoring investments would be ineffective. In its response, the DPU recognized that a more aggressive storm resiliency program was worthwhile to strengthening the company's distribution systems, mitigating some of the physical damage and financial impacts of future storm events to the benefit of ratepayers. The DPU's approval of both the PBR and the vegetation management

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[11] Docket No. 17-05, Issued 11/30/2017, Order Establishing Eversource Revenue Requirement, https://fileservice.eea.comacloud.net/V1.4.0/FileService.Api/file/FileRoom/dehehcjj, p. 367.

[12] Ibid, p. 378.

[13] Performance based ratemaking (PBR) is ratemaking mechanism that rewards a utility for meeting pre-determined key metrics. If metrics are met, utilities are allowed to earn certain returns (collected through rates from customers) that may be fixed or tied to specific performance. PBR can be employed in tandem with typical capital expense-based ratemaking and may also replace some sources of expense-based (traditional) ratemaking.

[14] Ibid, p. 379.

[15] Ibid, p. 402.

[16] Ibid, p. 407.

resiliency pilot highlight a potential pathway and mechanism for regulators to encourage longer term resilience planning and implementation by their regulated utilities.

Following this model, in 2018, Eversource began a tree resilience program and submitted to the DPU a report outlining the company's performance metrics around improvements to customer service/engagement, reductions in system peak, and strategic planning for climate adaptation.[17] Within its Climate Adaptation Plan, Eversource outlined the actions it plans to execute to "adapt the Company's infrastructure to the extreme weather conditions brought about by climate change." [18] These actions include: 1) prioritizing substations at risk for impact due to flooding over five years; 2) evaluate new equipment to improve performance in flooding conditions and provide a report on progress; 3) continue to harden the overhead system with Class 2 poles, composite cross-arms, and miles of covered wires over five years; 4) augment outage prediction model to include the climate impacts of riverine and coastal flooding by 2019.[19] While these planned items were specifically for reporting purposed and have not received official approval or funding from the DPU, they are the first step towards Eversource's targeted long term strategy.

Case Study: Con Edison Climate Change Vulnerability Study

In December 2019, Con Edison (ConEd) released a Climate Change Vulnerability Study that the New York Public Service Commission ordered and approved for funding. [20] The Commission directed the study to aid in the ongoing review of the company's design standards and development of a risk mitigation plan. ConEd explains further that the study will equip the utility with a better understanding of future climate change risks and strengthens the company's ability to more proactively address those risks. The study used an "integrated approach" to assess risks and review a portfolio of measures to improve climate resilience and establishes an overarching framework that can work to strengthen Con Edison's resilience over time.

Figure 1 illustrates the integrated approach utilized in the study. Using a foundation of internal expertise, this approach starts with a screen to identify and prioritize at-risk assets. The team then performed detailed analyses for the sensitive assets, including identifying a portfolio of adaptation options and qualitatively considering the financial costs, co-benefits, and resilience of each option. To identify areas of action in the face of irreducible uncertainties in projections of future climate conditions, the team used an adaptive implementation pathway approach to support flexible solutions that allow for effective risk management. This approach relies on a series of "signposts," which represent information that will be tracked over time to help Con Edison understand how climate, policy, and process conditions change and, in turn, trigger additional action.

[17] Docket No. 17-05, Issued 3/1/2018, NSTAR Electric Company and Western Massachusetts Electric Company each d/b/a Eversource Energy Performance Metrics for the Performance-Based Rate Making Mechanism, https://fileservice.eea.comacloud.net/FileService.Api/file/FileRoom/9167438.

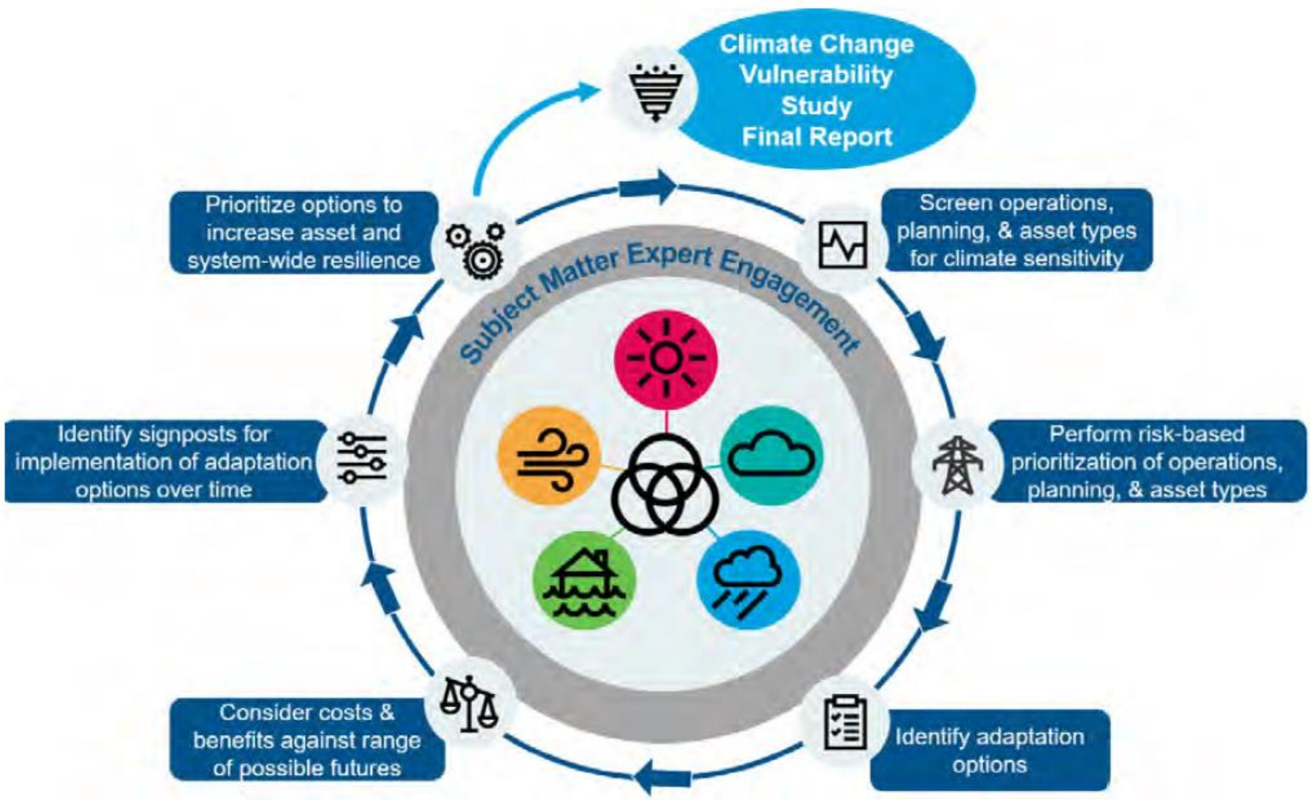
[18] Ibid. p. IV

[19] Ibid. p. 39

[20] Consolidated Edison, Climate Change Vulnerability Study, December 2019, https://www.coned.com/-/media/files/coned/documents/our-energy-future/our-energy-projects/climate-change-resiliency-plan/climate-change-vulnerability-study.pdf?la=en

These detailed analyses will inform the development of flexible solutions and the further prioritization of assets and options to increase systemwide resilience.

Figure 1. Integrated Study Approach

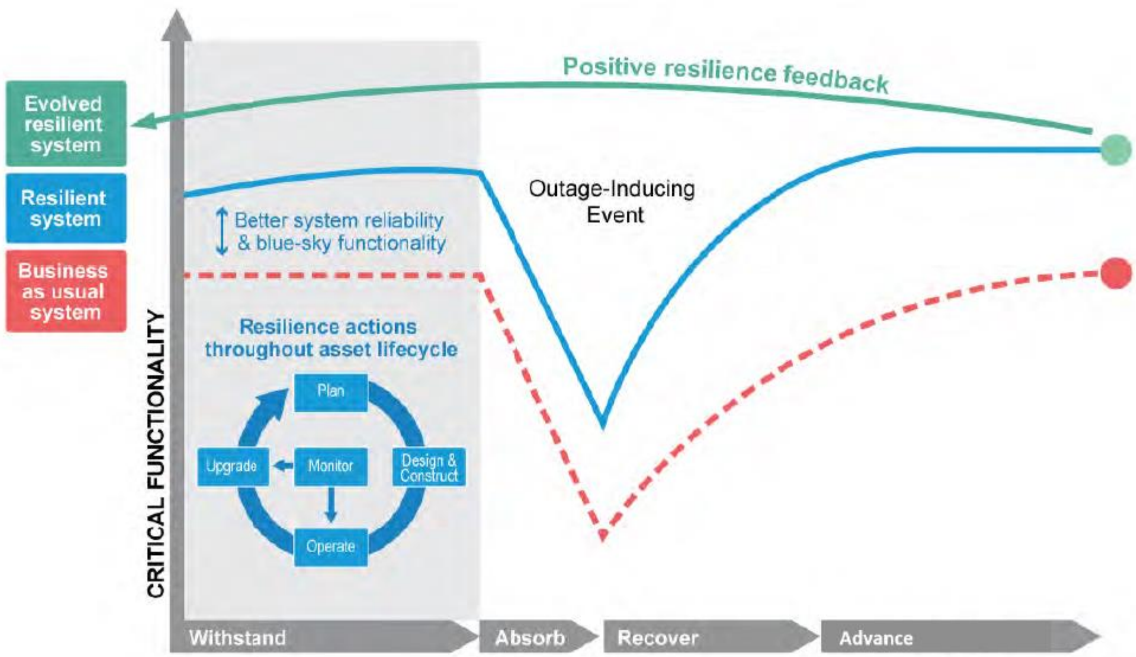


Source: ConEd 2019

The goal of this method is, by using comprehensive set of adaptation strategies, to build a system that can withstand changes in climate, absorb and recover from outage-inducing events, and advance to a better state. ConEd explains that a resilient system should better withstand, absorb, and recover from climate-driven conditions while advancing based on lessons learned. This "withstand" component prepares for both gradual (chronic) and extreme climate risks through resilience actions throughout the life cycle of assets. "Withstand" investments are not necessarily a one-time event, but may also include changes in the planning, design, and construction of new infrastructure; ongoing data collection and monitoring; and eventually investing in the upgrade of existing infrastructure, using forward-looking climate information. "Absorb" includes strategies to reduce the consequences of outage-inducing events, as a company cannot and should not harden its energy systems to try to withstand every possible future low-probability, high-impact extreme weather event. "Recover" aims to increase the rate of recovery and increase customers' ability to cope with impacts after an outage-inducing event, including prioritization of critical services. "Advance" refers to building back stronger after climate-related outages and updating standards and procedures based on lessons learned and revealed asset vulnerabilities.

Figure 2 shows how a resilient system would perform under each of these stages. Investing in a more resilient system (blue line) provides benefits relative to a less resilient, or business-as-usual, system (red dashed line) before, during, and after an outage-inducing event. Resilient systems also adapt so that the functionality of the system improves through time (green line). Each component of a resilient system requires proactive planning and investments.

Figure 2. Conceptual Resilience Management Framework



Source: ConEd 2019

In 2020, Con Edison intends to develop and file a Climate Change Implementation Plan, which will specify a governance structure and a strategy for implementing adaptation options over the next 5, 10, and 20 years. While this study assesses vulnerabilities within Con Edison's present-day systems to a future climate, the implementation plan will also consider the evolving market for energy services, and potential changes to services and infrastructure driven by customers, government policy and external actions over time.

Forward-looking cost-benefit analysis and consideration of climate risks

One of the most important, yet also most difficult, roles of a utility regulator is to review and approve (or reject) utility proposals for investments in its capital systems. However, resilience investments focused on future and growing climate risks can pose a challenge to the traditional way that utility regulators assess these investments. Generally, these investments or programs are designed to meet relatively rare circumstances, at least under historical conditions. Thus, relying on a historical assessment could, in some instances, lead regulators to view resilience investments as "over building" the system, increasing costs recovery requirements for rates in a way that is not necessary for those historical conditions. However, given the long-term nature of many utility investments, and their long implementation timelines, a reactive approach may not be appropriate. For example, by the time certain climate impacts are felt, it may be too late to build a system that is ready for those impacts—and past investments would have sunk millions into meeting standards that are too quickly outdated.

Accordingly, utility regulators must consider potential long-term impacts of climate change in planning and approval of system investments. Many utility investments are capital intensive and have a useful life measured in decades. Electric sector investments will need to be made taking into account a range of future conditions with a design standard that is appropriate for deterioration in conditions due to climate change. Such considerations may require a change in current practice, as many utility standards are based on historical and observed averages. It will be increasingly important, however, for utility regulators to acknowledge in their consideration of resilience plans and investments that the future may not mirror historical trends. Though the future impacts of climate change are not certain, ranges available through modeling and the tools mentioned above can help to guide consideration of investments. These future conditions also must be realistically considered in planning to determine an appropriate balance between system risk reduction and spending. Even a proactively and comprehensively designed grid will experience some outages under severe conditions (climate-induced or otherwise); incorporating long-term projections of climate conditions into planning and analysis will help to identify and strike this balance.

These impacts must also be tailored to local needs and conditions so that utilities can plan for the granular and detailed effects on their systems and customers. The solutions and investments in the Southwest, where drought, heat waves, and wildfire are a large part of the current and projected climate change experience, will likely be different than those that would be most effective in the Northeast, where severe storms and rising sea levels pose more of a risk. Utility regulators must, therefore, ground their efforts based on local conditions. There are numerous already-created resources at the national level that aid utility regulators in this process, such as many components of the U.S. Climate Resilience Toolkit.[21] In addition, some states, cities, and localities have conducted their own assessments, such as California's CalAdapt portal.[22]

Finally, when reviewing forward-looking resilience investments, regulators may need to establish updated methods to consider the "value" of resilience for many existing and emerging technologies. Such methods should consider both the benefits and the challenges of resources such as distributed generation, which can help to provide localized services in the case of outages but also can be location-limited at relatively high cost. For example, existing metrics for reliability focus on short term outages rather than longer term resilience or climate risks. Additionally, many technical standards for distributed energy resources require that these resources completely disconnect from the grid in times of outages, meaning that any value they could provide during these times is negated. A recent study by NARUC explores different ways utility regulators could consider analyzing the resilience value of certain resources. While the study focused on distributed resources, many of the principles could apply to other investments such as distribution system hardening. For example, the study highlighted four different ways of valuing resilience attribute of resources that include both theoretical/modeling-based approaches as well as economic data collection and survey methods. Utility regulators could use these and other emerging

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21 U.S. Climate Resilience Toolkit. https://toolkit.climate.gov/

22 CalAdapt: Exploring California's Climate Change Research. https://cal-adapt.org/

models to improve analysis of possible resilience solutions and ensure that the most effective, least cost solutions are adopted.[23]

Case Study: Entergy "Building a Resilient Energy Gulf Coast" Plan

Entergy's "Building a Resilient Gulf Coast Plan" develops a new cost-benefit analysis framework that incentivizes forward looking resilience planning.[24] Entergy's plan focuses on ways to size risk based on how extreme—low, medium, and high—the future climate change will be and, based on that assessment, generates an expected loss scenario that evaluates hazard, value, and vulnerability models for each climate change scenario.

$$\begin{aligned} &\text{Expected loss per climate change scenario} \\ &= \text{hazard model} * \text{value model} * \text{vulnerability model} \end{aligned}$$

Whereas other cost-benefit models focus on shorter-term planning horizons, Entergy's analysis evaluates potential near-term resilience efforts that will lead to cost savings in the longer term as the frequency and severity of storms increase. The cost-benefit analysis discounts lifecycle costs to capture present value benefits in order to evaluate potential long-term impact. This type of valuation enables increased near term investment which can dampen future loss. Such valuation is critical to resilience planning.

As part of this framework, Entergy has valued different asset classes by either their economic value or their ability to diminish business interruption. One critical asset evaluation is the granular assessment of electric and gas utility assets. Entergy's analysis of the Gulf Coast found that oil and gas industry sectors contribute to a significant share of annual expected loss in a 2030 timeframe.[25] Entergy's analysis found that cost beneficial utility measures, like vegetation management and resilient distribution lines, can avoid $830 million of the projected losses in 2030. Factoring these future losses into cost-benefit analyses could enable longer term utility resilience projects to pass cost effectiveness tests and be implemented, ultimately saving utilities and ratepayers money in the long term.

Since the publication of its 2010 framework, Entergy has continued to deploy storm hardening initiatives and has initiated pilot projects in two ports—Port Arthur in Texas and Port Fourchon in Louisiana—that were particularly vulnerable along the coast.[26] The Port Author pilot project is anticipated to be completed in 2020.[27]

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23 *The Value of Resilience for Distributed Energy Resources: An Overview of Current Analytical Practices* National Association of Regulatory Utility Commissioners, April 2019, https://pubs.naruc.org/pub/531AD059-9CC0-BAF6-127B-99BCB5F02198

24 *Building a Resilient Energy Gulf Coast: Executive Report*, Entergy, 2010, https://www.entergy.com/userfiles/content/our_community/environment/GulfCoastAdaptation/Building_a_Resilient_Gulf_Coast.pdf.

25 Ibid. p. 6

26 *Comments on the Quadrennial Energy Review April 11, 2014 Public Meeting "Enhancing Infrastructure Resilience and Addressing Vulnerabilities," Held in Washington, DC*, Entergy Operating Companies, October 10, 2014. https://www.energy.gov/sites/prod/files/2015/04/f21/Entergy%20Responses%20to%20Key%20Questions%20Regarding%20Energy%20System%20Vulnerabiliti....pdf

27 "Entergy Texas Kicks Off Construction of Port Arthur Reliability Transmission Project," Entergy News Room, October 29, 2018, https://www.entergynewsroom.com/news/entergy-texas-kicks-off-construction-port-arthur-reliability-transmission-project/

Case Study: Florida Utilities

Florida is expected to experience a wide range climate change risks. One increasing risk is that of hurricanes and tropical storms, which can be some of the largest natural disasters nationwide in terms of economic disruption and damages. Over the past decade, the state has taken action to harden utility systems to respond to these storms.

The Florida PSC and its regulated utilities have a long history of developing storm preparedness policies. For example, starting in 1992, the Commission developed its first storm cost risk mitigation plan for IOUs. Since then, the PSC has provided several recommendations that have enabled utilities to incorporate up to date projections and data into their infrastructure hardening efforts.

In 2006, spurred by significant hurricane seasons in 2004 and 2005, the PSC required IOUs to document the effectiveness of their investments in storm hardening technology by collecting and monitoring outage data during storms in addition to other storm preparedness initiatives including: 1) developing a six-year transmission structure inspection program; 2) hardening existing transmission structures; 3) developing transmission and distribution geographic information systems; 4) collecting post-storm data and forensic analysis; 5) collecting a detailed outage data differentiating between reliability performance of overhead and underground systems; 6) collaborating on research on the effects of hurricane winds and storm surge; and 7) developing a natural disaster preparedness and recovery program plan.

In November 2017, the PSC asked IOUs to review their hurricane preparedness and restoration actions by assessing their damage assessment process, restoration workload and staffing needs, as well as storm impact on hardened/non-hardened infrastructure after the 2017 hurricane season.[28] The Commission held a workshop on this topic in May of 2018 and issued a summary document that highlighted the key takeaways from the meeting finding: 1) data collected during and after a 2017 storm show Florida's aggressive hardening programs work; 2) hardened overhead facilities substantially lower failure rates; 3) underground facilities had minimal failure rates; 4) three largest IOUs currently have 37.6% of distribution lines underground; and 5) public expectations for a lower number of outages and restoration times is rising, indicating resilience and restoration have to improve.[29]

In requiring data collection and projections, the PSC enabled IOUs throughout Florida to have a much better understanding of the impacts of hardening infrastructure on storm preparedness, which encouraged increased investment from IOUs within the region. For example, since 2004, Duke Energy has invested more than $2 billion to harden its electrical system in Florida and plans to invest $3.4 billion over the next 10 years to further modernize the grid including advanced self-healing technology, hardening and resiliency, advanced metering infrastructure, and targeted undergrounding.[30] Since the

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28 Document No. 09780-2017, Issued 11/14/2017, in Docket No. PSC- PSC-20170215-EU, Review of Electric Utility Hurricane Preparedness and Restoration Actions. http://www.floridapsc.com/library/filings/2017/09780-2017/09780-2017.pdf

29 Document No. 04236-2018, Issues 6/14/2018, in Docket No. PSC-20170215-EU, Review of Electric Utility Hurricane Preparedness and Restoration Actions. http://www.floridapsc.com/library/filings/2018/04236-2018/04236-2018.pdf

30 Ibid.

2004-2005 hurricanes, Florida Power & Light Company has invested $4 billion in grid resilience including strengthening transmission lines, replacing poles and clearing vegetation from more than 150,000 miles of power lines.[31]

Furthermore, when the PSC asked IOUs to compare their responsiveness to storms before and after increased storm hardening efforts, several noted decreased outages and restoration times. Florida Power and Light found dramatic differences in restoration time after implementing storm hardening projects when it compared Category 5 hurricanes from 2005 and 2017. For example, Florida Power and Light took one day to restore power to 50 percent of its customers during Hurricane Irma in 2017 whereas it took five days to restore power to 50% of its customers during Hurricane Wilma in 2005. TECO and other IOUs also noted similar reductions.[32]

Finally, the Florida PSC recently received new direction from legislation passed in the 2019 session. The bill, SB 796,[33] requires utilities to submit, on an annual basis, a transmission and distribution storm protection plan that covers the following 10 years. The PSC is also required to conduct an annual proceeding to allow utilities to recover certain costs through these storm protection plans. The legislation specified that if these costs were "prudently incurred," such costs are not subject to disallowances or reviews. Cost are to be recovered, not through base rates, but instead through a separate bill surcharge. The legislature noted that "protecting and strengthening transmission and distribution electric utility infrastructure from extreme weather conditions can effectively reduce restoration costs and outage times to customers and improve overall service reliability for customers," and that all customers would benefit from reduced costs.

Situation-specific and responsive resilience metrics and goals

As utility regulators begin to consider ways to support the development a more resilient grid, it is important to both define and develop a set of metrics to quantify resilience that are specific to the needs of electric utilities and grid operators. Regulators, grid operators, and utilities have created universal metrics around reliability but have not done the same for resilience, in part because of the location-specific needs of resilience planning. Responsive metrics will be critical for designing grid improvements and measuring progress. Metrics also must be designed to allow a reasonable level of risk, recognizing that even a proactively and comprehensively designed grid will experience some outages under severe conditions (climate-induced or otherwise).

Sandia National Laboratories released a report in 2017 that discussed this dilemma noting that: 1) current resilience definitions are too imprecise to be used in regulatory analyses; and 2) existing reliability standards do not capture additional costs and resources related to implementing resilient infrastructure.[34] The report discussed the importance of creating a resilience process that is unique but comparable to reliability metrics. While the *process* should be uniform, the resulting *metrics* would differ depending on the location and situation-specific risks that a utility faces. Utility regulators are well-placed to lead or guide this metric-development process for the utilities that it regulates.

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31 Silverstein et. al, *A Customer-focused Framework for Electric System Reliance*, Grid Strategies, May 2018. https://gridprogress.files.wordpress.com/2018/05/customer-focused-resilience-final-050118.pdf, p. 58.

32 Document No. 04236-2018, http://www.floridapsc.com/library/filings/2018/04236-2018/04236-2018.pdf.

33 Florida Senate Bill 796: Public Utility Storm Protection Plans. https://www.flsenate.gov/Session/Bill/2019/00796/

34 Eric Vugrin et. al. *Resilience Metrics for the Electric Power System: A Performance-Based Approach*, Sandia National Laboratories, February 2017, https://prod-ng.sandia.gov/techlib-noauth/access-control.cgi/2017/171493.pdf.

As part of its analysis, Sandia National Lab recommended that a power system's resiliency be measured in terms of consequences that will result if a hazard occurs. Instead of defining specific metrics that must be addressed by every utility, the report recommends a process by which utilities could define specific goals around resilience. Based on its analysis, the report recommended the following process, also displayed in Figure 3. Utility regulators could use this, or a similar model, as a process for local resilience metric development and assessment.

1. **Define resilience goals:** Develop an internal team that incorporates all relevant departments and set a broad goal.
2. **Define consequence categories and resilience metrics:** Focus on the categories and metrics that directly impact the utility, such as loss of service or critical assets when defining consequence estimates and resilience metrics.
3. **Characterize hazards:** Determine which hazards should be included based on utility specific metrics.
4. **Determine level of disruption:** Define the level of damage or stress that grid assets are anticipated to suffer under certain hazard scenarios.
5. **Collect data via system model or other means:** System level computer models can provide necessary power disruption estimates.
6. **Calculate consequences and resilience metrics**: Utilize statistical analyses—such as confidence intervals, value at risk (VaR), and conditional value at risk (CVaR)—that can help define uncertainty.
7. **Evaluate resilience improvements:** Assess potential benefits and costs of resilience options.

Figure 3. Resilience Analysis Process

Source: Sandia National Lab

In addressing resilience in this way, regulators, grid operators and utilities are able to identify key risks and prioritize resilience planning through a uniform procedure that is widely accepted by utilities and grid operators alike.

Case Study: SDG&E Flexible Adaptation Pathways

SDG&E, as part of California's 2013 rulemaking, conducted a detailed analysis evaluating how its existing infrastructure will be impacted given different sea level rise (SLR) projections.[35] In addition to assessing risks to their own service territory, SDG&E evaluated community-wide risks—looking at the potential costs to underserved communities in addition to costs to critical customers—such as naval yards, hospitals, and port and sewage stations within its service territory. This analysis was conducted using impact scenarios which varied in SLR impacts and conditions. For example, Impact Scenario 1 assumed future periodic tidal inundation and 6.6 feet SLR, while Impact Scenario 3 assumed extreme future storm coastal wave flooding under a 100 year storm and 6.6 feet SLR. These scenarios were designed to further address the potential key interdependencies between the electric system and other critical infrastructure.

As part of this modeling exercise, SDG&E developed a series of flexible adaptation pathways to determine which actions to take to create a more resilient electrical system.[36] The pathways are designed to be adjusted overtime as new information or circumstances emerge. SDG&E developed several policy actions that fit into its pathways methodology including both short term actions—such as enhancing coastal storm prediction and response—and long-term actions—including asset and site relocation, among others. Each of these actions are mapped into a suite of forward-looking actions that create a more resilient system for SDG&E, displayed in Figure 4. In developing a framework and series of adjustable metrics, SDG&E has a plan to move forward but also has the flexibility to adjust the plan as new information is gathered, ultimately making its resilience planning process more proactive and beneficial for long-term performance.

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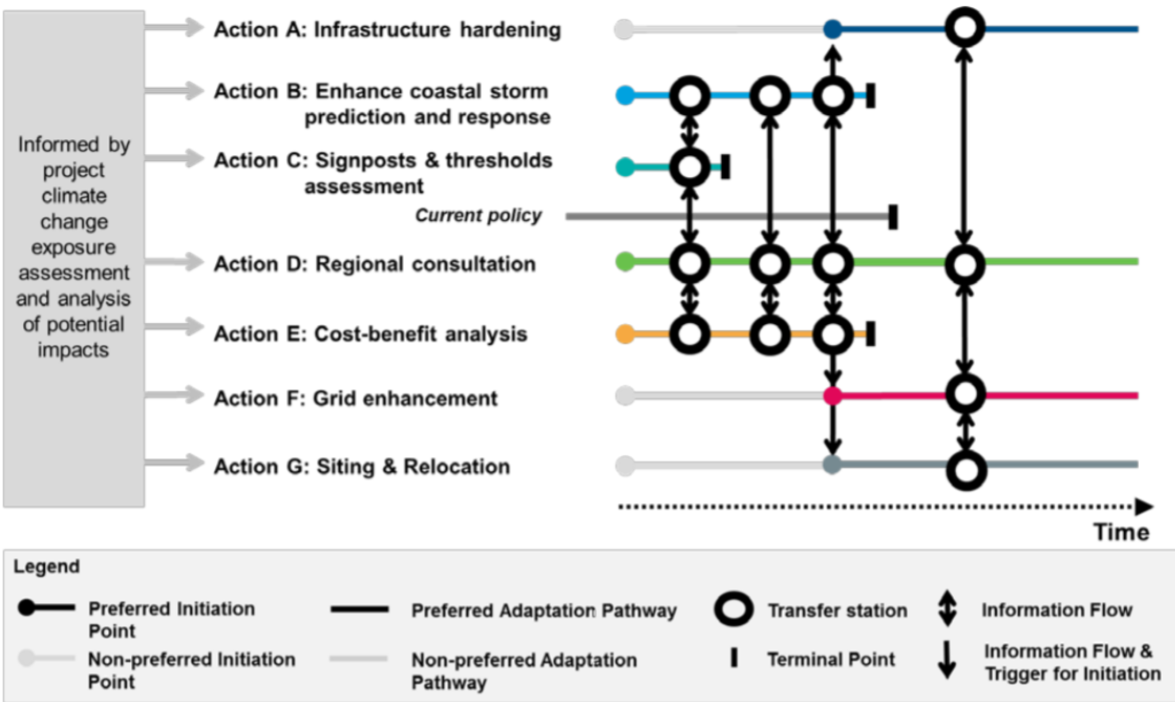
35 CA PUC Rulemaking 13-11-006

36 Bruzgul, Judsen, et al. (ICF and Revell Coastal). 2018. Rising Seas and Electricity Infrastructure: Potential Impacts and Adaptation Actions for San Diego Gas & Electric. California's Fourth Climate Change Assessment, California Energy Commission. Publication Number: CCCA4-CEC- 2018-004.https://www.energy.ca.gov/sites/default/files/2019-07/Energy_CCCA4-CEC-2018-004.pdf

Figure 4. Initial Flexible Adaptation Pathway Map



Source: SDG&E

Data collection and dynamic assessment

A critical component to beginning any planning process is understanding how current infrastructure and policies function. As the adage goes, you can't manage what you don't measure. For many utilities across the United States, climatic shifts are already changing the way that utility infrastructure performs. Whether it is increased flooding and erosion, ice storms, or fires, utilities are now required to assess existing infrastructure and target locations that may need technical upgrades to withstand new climate conditions. Data collection and dynamic assessment of system performance are critical elements to this process to ensure that infrastructure upgrades are optimized to respond to the events or conditions with the largest impacts—and that these investments are providing the desired improved resilience. Over time, as we learn more about climate change and its impacts, it is likely that the system data collected will change; utilities and utility regulators should regularly assess available information for gaps and new questions.

System performance data collection can also provide information needed to build regulatory support for increased infrastructure spending. This will be critical to understanding the vulnerability of utility assets and the value of upgrading them. For example, several utilities in Florida have started to monitor the effectiveness of their storm hardening processed to determine if implementing underground wires and other storm hardening initiatives has led to increase responsiveness to customers during hurricanes.[37] As discussed above, data collection and

[37] Document No. 04236-2018, Issues 6/14/2018, in Docket No. PSC-20170215-EU, Review of Electric Utility Hurricane Preparedness and Restoration Actions. http://www.floridapsc.com/library/filings/2018/04236-2018/04236-2018.pdf

assessment are also critical to developing forward looking cost-benefit analysis and responsive planning that take into consideration a changing climate.

Utility regulators can support this data collection in numerous ways. First, they can work with other agencies to develop statewide resources on climate risks and impacts. Data on how climate change has affected the state can be important foundations for future actions. Utility regulators, through their expertise and by soliciting requests and feedback from utilities, can help to shape this data collection to be sure that it contains metrics and information that are specifically useful in gauging and then ameliorating risks faced by the electric sector. Second, utility regulators should support utilities' in-house data assessment and collection. This could include approving advanced metering infrastructure or partnerships to help utilities process incoming data. Third, utility regulators could consider creating a mechanism for utilities to share this information, while ensuring that customer privacy is protected. Together, these actions can help utilities to share findings, best practices, and identify possible patterns across the state.

Case Study: CenterPoint

Since 2010, the State of Texas has required all electric utilities to develop and submit a Storm Hardening Plan that highlights cost effective strategies to improve, "all activities related to improved resiliency and restoration times including emergency planning, construction standards, vegetation management, and other actions before, during, and after extreme weather events."[38] As part of this planning process, CenterPoint has increased its on-line monitoring equipment, limited the construction of large overhead transformer banks, and developed an Underground Residential Distribution Cable Life Extension program in addition to evaluating and implementing required vegetation management, emergency planning, and construction standards that improve system reliability and resilience.[39]

These investments in advanced metering systems have allowed the utility to maintain reliability more effectively during extreme weather events like Hurricane Harvey in 2017. CenterPoint's investments in an advanced metering system allowed them to execute 45,000 operational orders remotely at 97% performance accuracy ultimately allowing them to avoid 41 million outage minutes following Hurricane Harvey.[40]

The state's requirement for every electric utility to update their storm hardening plan every five years and to notify the PUC of any material changes to the plan annually, encourages CenterPoint and other utilities within Texas to evaluate and improve their planning processes as conditions change within their service territory.

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[38] Texas Admin. Code Ann. §25.95, adopted to be effective July 13, 2010. http://txrules.elaws.us/rule/title16_chapter25_sec.25.95

[39] Project No. 39339, Issued 5/1/2019, Storm Hardening Plan Summary of CenterPoint Energy Houston Electric LLC, Pursuant to 16 Tex. Admin. Code http://interchange.puc.texas.gov/Documents/39339_128_1016273.PDF.

[40] Deryl Tumlinson, *Texas Strong: Hurricane Harvey Response and Restoration*, CenterPoint Energy, May 2018. https://www.rmel.org/rmeldocs/Library/Presentations/2018/SPRING18/SPRING18_Tumlinson.pdf

Climate Resilience and State and Local Policymakers

Utilities operate within the context of their state and local policy contexts. Publicly owned utilities, in particular, are quasi-governmental bodies themselves, with locally appointed governing boards and direct accountability to mayors or governors. However, investor owned utilities and cooperatives are also strongly shaped by the need to comply with state, city, and other local clean energy, climate adaption, mitigation, or related policies. These policies can stem from myriad agencies, including Departments of Environment, Energy, or Planning as well as Governors or Mayors offices. City councils and state legislatures also often create policy mandates that drive utility action.

Key State and Local Roles

This range of state and local of these policymakers are all part of the resilience ecosystem in which utilities plan, operate, and respond to disasters and other climate conditions. In the context of resilience investments and planning, these policymakers play three primary roles.

First, state and local policymakers set overarching climate and resilience goals or planning processes. Often these are set through executive action—Governor Executive Order, for example—but other times they are legislative or regulatory driven. These goals and targets can provide important framing and context for utility regulators, providing guidance for how utility regulators should view utility investments, and perhaps even creating the impetus for a specific proceeding and request for utility resilience plans. As discussed above, utility regulators have historically viewed investments and spending approval through a specific set of criteria and cost-benefit analyses. State or local resilience requirements can help to update or add important considerations to these utility regulatory processes.

Second, state and local policymakers are in an important position to guide utility resilience investments in a way that both reinforces and draws upon broader resilience efforts. For example, states may have in place procedures for responding to severe storms that rely on reliable and resilient electric service—emergency response agencies and evacuation centers may have certain requirements or plans in place. Utilities can best align with these efforts and requirements if they are aware of existing plans and possibly part of their development process. Similarly, when utilities are making plans for protecting or restoring service, they are likely to rely on other local resources, such as roads and communication networks. Understanding the processes that the operators of these resources have in place to make them more resilient will help utilities design realistic resilience investments and strategies. State and local policymakers can facilitate this exchange of information and best practices and can help coordinate across diverse parties. More broadly, these state and local policymakers, with a broad jurisdiction and regulatory purview, can help to create stakeholder dialogue and build coalitions of affected parties.

Third, state and local policymakers are an important source, and distributor, of resilience funding. While many utilities incorporate resilience investments into ongoing investment and rate cycles, states and local governments are also likely to have other sources of revenue that can assist utilities in ensuring that their systems are prepared to support their local communities through climate changed conditions.

Key State and Local Considerations

Just like utility regulators, each state, city, and locality will approach climate resilience investments through the lens of its local conditions. This section highlights some of these key considerations.

State or local targets for resilience and climate adaptation

Many states, cities, and other local governments already have existing resilience targets and plans. These can range in scope and level of detail. These plans are often very broad, including far more than the electric sector:

for example, plans may include a discussion of a range of resiliency conditions, such as cybercrime or terrorism, as well as climate impacts. Because of their broad scope, however, they may provide a different and important view on resilience that can be paired with the utility-specific resilience strategy noted above. Additionally, such local and state plans can be an important catalyst for utility and utility regulatory action by laying out high level goals, desired utility performance or actions, or descriptions of critical services.

Some plans may set general goals, while others lay out specific roadmaps of action. Los Angeles, as discussed more in the case study below, has established a broad set of nearly 100 actions that stakeholders across the public and private sphere should take to improve disaster preparedness and recovery, increase economic security, modernize infrastructure, and prepare for climate change adaptation. This plan was years in the making. A location earlier in the process is North Carolina, as mentioned above, where Executive Order 90 directed all cabinet agencies to integrate climate adaptation and resiliency planning into their policies, programs, and operations. The North Carolina Department of Environmental Quality has additional requirements, including developing a statewide Climate Risk Assessment and Resiliency Plan, helping to create a North Carolina Climate Science Report, and hosting regional stakeholder workshops.[41]

When developing these plans, states and local governments should consider how they can help provide structure and guidance for utility action. For example, they could include specific climate adaptation targets for electric sector action. They could also help to clearly articulate the expectations that the state or local government has for the electric sector in times of climate disasters or under future conditions, which can help utilities build an investment roadmap to meeting those requirements. States and local governments should also include utilities, and utility regulators, in the development of these plans to ensure that such goals and expectations are reasonable and aligned with ongoing investment plans and schedules.

Case Study: Resilient Los Angeles

The City of Los Angeles and the Los Angeles Department of Water and Power (LADWP) have developed a robust resilience playbook that centers around the critical shocks and stressors that impact Los Angeles' resilience to climate change. As a 100 Resilient City member, the Chief Resilience Officer is tasked with evaluating the city's chronic shocks and stressors and developing a framework to address those unique characteristics within the city. In 2018, the City released its first resilience plan which identified 15 goals and 96 actions for the city and its partners to implement.[42]

As a municipally owned utility, LADWP is directly tasked by the city to implement several resilience goals and initiatives as part of the city's resilience plan. The city has set the following goals: 1) modernize the power grid to expand renewable energy to make up 65% of the city's power source by 2036 while deepening storage capacity and broadening emergency backup systems; 2) reduce water and energy consumption through LADWP incentives; 3) replace more than 70% of the existing power supply by modernizing aging power grid infrastructure; and 4) create public education and messaging around risk reduction and preparedness. Each of the above goals includes a set of tasks, a broad timeframe, and a list of partners that are responsible for executing the task. While the resilience plan is still relatively new, LADWP has already begun to

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41 *Climate Risk Assessment and Resiliency Plan*, North Carolina Department of Environmental Quality. https://deq.nc.gov/energy-climate/climate-change/nc-climate-change-interagency-council/climate-change-clean-energy-0

42 *Resilient Los Angeles*, City of Los Angeles, March 2018, https://www.lamayor.org/sites/g/files/wph446/f/page/file/Resilient%20Los%20Angeles.pdf

implement several resilience initiatives as part of its resilience strategy including installing energy and storage pilots and developing Smart Grid LA which will test advanced smart grid technologies on 52,000 residential customers in three areas of LA around the USC and UCLA campuses.

In many ways, the LA and LADWP resilience planning partnership is unique due to LADWP's relationship to the city as a municipally owned utility and because the city was selected to be a 100 Resilient City member. Both factors have contributed to increased resilience planning and funding for resilience initiatives and have also led to a potentially more direct interaction between city and utility resilience planning as both entities share the same service territory shocks and stressors.

Localized data and resources

In the same way that utility regulators can support the development of data to assess electric sector resilience, local and state policymakers can be an important conduit for climate adaptation research and resources. These resources can take three main forms:

- **Climate science and modeling**: one of the difficulties in projecting the effects of climate change is that they will vary significantly by season and region. Therefore, while national and regional resources may contain some useful information, many climate model results may need to be accurately downscaled to state or local scales to provide the level of detail needed for accurate planning. States and local governments can help to manage and conduct this downscaling to provide results that are useful for local stakeholders.
- **Local projections of impacts**: states, cities, and other local governments can help to then translate these climate change risks to impacts on local communities, businesses, and infrastructure. These policymakers have knowledge of local systems, planning processes and future investments, and populations and also have access to input from stakeholders. They are, therefore, well-placed to conduct informed, coordinated, and granular assessments of climate impacts.
- **Public dashboard for programs, plans, funding opportunities**: building communities resilient to climate change will require coordination across many parties (see discussion below). Agencies, companies, and other stakeholders are all likely to take action, provide resources, offer funding, and set up programs to assist communities in improving their infrastructure and operations. To ensure that these efforts are both coordinated and made available to those who qualify for them, local governments and states could consider establishing a centralized resource dashboard that helps to organize these myriad resources and create a "one stop shop" for stakeholders to take resilience action. In addition, a dashboard can help to increase transparency and track progress of commitments across stakeholders.

While some states and cities have these resources and initiatives in place, there remain many opportunities to expand and further develop resources in many other locations. Policymakers can look to existing models, as well as federal resources, to support the development of new state or city programs.

Case Study: New Jersey Science and Technical Advisory Panel Report

Since 2015, Rutgers University has convened the New Jersey Science and Technical Advisory Panel (STAP) on Sea-Level Rise (SLR) and Coastal Storms to prepare New Jersey communities for the effects of climate change by incorporating current local sea level rise (SLR) projections into risk-based decision-making processes. The panel was charged with: 1) identifying and evaluating the most current science on SLR projections and changing coastal storms; 2) evaluating the implications of SLR on local and regional stakeholders, and; 3) identifying planning options and potential guidelines that stakeholders could utilize to increase the resilience of New Jersey's coastal communities.

New Jersey, like several northeastern states, faces both severe and rapid SLR in addition to other, often compounding issues, such as tidal flooding and increased storm surges. These effects will impact certain regions within the state more than others thus creating a need for localized modeling and planning in order to ensure the resilience of communities across New Jersey.

To date, STAP has released two technical reports: one, in partnership with the New Jersey Climate Alliance, in 2015[43] and a second, in partnership with the New Jersey Department of Environmental Protection, in 2019.[44] Each STAP analysis began by conducting a literature review of New Jersey's predicted SLR looking specifically at changing relative sea levels and changing coastal storms. The panel then created SLR projections based upon low, medium, and high emissions scenarios[45] and proposed planning horizons to discuss the implications that the estimated SLR will have on New Jersey's coastal communities and ecosystems. The data and various scenarios are publicly available in an online data visualization and mapping platform, the New Jersey Floodmapper.[46] In addition to its technical analyses, STAP also convenes a panel of practitioners who recommend how the science and analysis should be implemented into state and local planning and decision making.

This scenario-based planning approach enables planners and other practitioners to better understand the current modeling around climate change so that they can begin to incorporate that analysis into comprehensive planning documents. While STAP does not provide detailed planning methods, it does enable practitioners to begin to think about the varying degrees of risk associated with a changing climate and to use localized data to drive decision-making.

Resilience action coordination

Creating resilient communities will require proactive electric utility action, but that alone will not be enough. Electricity is a critical service and one that becomes even more so in times of crisis. Utilities will need to know how demands on its system will change as other sectors, such as health care and emergency response, update their processes to increase climate resilience. Furthermore, utilities themselves rely on other services such as transportation and communication networks to maintain and operate their systems through times of stress. Utilities also serve a wide range of communities, each with distinct needs and many with resilience plans of their own.

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43 Kopp, R.E., et al. 2016. Assessing New Jersey's Exposure to Sea-Level Rise and Coastal Storms: Report of the New Jersey Climate Adaptation Alliance Science and Technical Advisory Panel. Prepared for the New Jersey Climate Adaptation Alliance. New Brunswick, New Jersey.

44 Kopp, R.E., et al. 2019. New Jersey's Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel. Rutgers, The State University of New Jersey. Prepared for the New Jersey Department of Environmental Protection. Trenton, New Jersey.

45 STAP utilized Representative Concentration Pathways utilized in international integrated assessment models used by the Intergovernmental Panel on Climate Change (IPCC).

46 "New Jersey Floodmapper," Rutgers University, https://www.njfloodmapper.org/.

Utility resilience strategies must be coordinated with these and other stakeholders. State and local policymakers can create forums for sharing information, exchanging best practices, and creating accountability across parties, especially across sectors that may not have existing communication pathways or relationships.

Case Study: Chicago and Commonwealth Edison

The City of Chicago and Commonwealth Edison (ComEd) have worked together since 2018 to identify opportunities for increased energy resilience. As a 100 Resilient City member, the City of Chicago's Chief Resilience Officer is tasked with evaluating the city's chronic shocks and stressors and developing a framework to address those unique characteristics within the city. In 2019, the city released its first resilience plan, which identified several goals to develop a resilient energy system including: 1) developing distributed energy resources and resilience; 2) creating partners in building resilience; and 3) increasing income-eligible energy efficiency programs.[47] These goals were developed in partnership with ComEd through a series of working sessions that brought the city and utility to the table to identify areas that could be enhanced by deeper collaboration.

As part of this collaboration, the city identified a set of relevant partners within the city, including Chicago's Fleet and Facility Management (2FM), Office of Emergency Management (OEMC), Transit Authority (CTA), Department of Public Health (CDPH), Department of Family and Support Services (DFSS) and Department of Transportation (CDOT), to partner with ComEd to implement each of the above goals and also identified current and future projects that the city in partnerships with others will work on going forward. For example, under its goal of distributed energy resources (DER) and resilience, the city tasked ComEd with the following initiatives: 1) collaborate to select up to five sites to reduce carbon emissions, enhance grid and community resilience, and support the emergence of a smart city and 2) identify how existing city distributed energy resources can be connected to the Bronzeville Community Microgrid, how microgrids can protect critical city facilities and where new, low carbon DER assets should be installed. Notably, Chicago has also highlighted future grants and funding opportunities to increase the development of these programs and initiatives.

In addition to these city-utility partnerships, the city has also created several partnerships with ComEd and other non-governmental associations and nonprofits to support additional initiatives outlined in their resilience plan. For example, the city created a multi-year partnership between the American Society of Heating, Refrigerating and Air-Conditioning Engineers of Illinois, Building Owners and Managers Association of Chicago, C40, Chicago Association of Realtors, Chicagoland Apartment Association, Midwest Energy Efficiency Alliance, National Resource Defense Council, Peoples Gas, Illinois Environmental Council, US EPA, and US DOE, among others, to improve the energy efficiency of Chicago's buildings. This partnership's near-term goal is to develop and implement an energy rating system for buildings required to benchmark under the 2013 Benchmarking Ordinance and to recruit 100 participants to the Retrofit Energy Challenge program by 2020.[48]

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47 *Resilient Chicago: A Plan for Inclusive Growth and a Connected City*, City of Chicago, February 2019, https://resilient.chicago.gov/download/Resilient%20Chicago.pdf

48 Ibid. p. 105

While these initiatives are still in the early implementation stage, the city's initial engagement of bringing ComEd into planning discussions is a critical first step in ensuring that a city-utility partnership can continue to grow as new resilience projects are developed.

Funding opportunities to support or complement utility resources

To date, many investments to improve electric sector climate resilience have been funded through typical utility channels (*i.e.*, customer funded through rates). For many investments going forward, this will likely remain appropriate. And, as discussed above, utility regulators will need to assess and approve these investments using a forward-looking cost benefit analysis that takes into account changing conditions on the grid.

However, as community climate resilience needs grow, there may be other sources of funding that can complement utility-sourced funding and help to ensure that proactive and comprehensive investments can be made across communities. For example, some communities may wish to develop local microgrids to support essential services, like hospitals or emergency response centers. Such grids could be developed through a partnership with utility funding and community funds, supported by state or local grants or incentives. This model is seen in many other contexts across the electric sector, such as state-provided rebates for electric vehicle chargers paired with utility investment in the infrastructure to support those chargers, or energy efficiency programs that are funded through a combination of utility funds and state incentives or tax credits.

Case Study: Pepco DC Climate Resilience Activities

Since 2012, Pepco has worked in partnership with the District of Columbia (DC) to increase its system resilience through the implementation of its DC Plug Program and its recently approved Capital Grid Project. Together, these initiatives, which underground electrical lines and upgrade and strengthen existing substations, display Pepco and the Districts' demonstrated desire to work together to increase grid reliability and enhance system resilience.

Since 2017, the DC Powerline Undergrounding (DC PLUG) Initiative has been identifying and undergrounding some of the most vulnerable power distribution lines within the District. The initiative was the byproduct of the Mayor's Power Line Undergrounding Task Force— created by an August 2012 Mayoral Order—consisting of an 18 member panel of government officials, regulators, local utility industry executives, and residents of neighborhoods affected by power outages. In 2013, the Taskforce recommended that the District Department of Transportation (DDOT) partner with Pepco to underground identified primary electric lines. In 2017, the DC Council passed the Undergrounding Act which required Pepco and DDOT to file biennial plans to achieve this goal. Pepco and DDOT jointly filed their first plan in 2017, which made DDOT responsible for constructing underground facilities and Pepco responsible for installing underground electric distribution for overhead feeders known to be affected by outages.[49]

A unique component of this public-private partnership is how it is funded. The Public Service Commission of DC approved funding of $500 million for the DC PLUG Initiative, $250 million of which was funded through Pepco rates with the remaining coming from

[49] "DCPSC Approves Second Biennial Plan for DC Plug," Public Service Commission of the District of Columbia, https://dcpsc.org/DCPLUG.

the District.[50] Pepco customer bills now include two annually adjusted surcharges to recover the costs of the Pepco funding in addition to $187.5 million of the District's funding obligation (which is shown on bills as a District tax). Pepco recovers its costs through a tariff rider authorized under the Undergrounding Act signed by the Mayor in 2017. The remaining $62.5 million comes from DDOT's capital improvement budget. DDOT and Pepco are required to submit an updated plan to be approved by the Commission every two years.

In addition to its DC PLUG initiative, Pepco recently received approval for its Capital Grid Project, a forward-looking plan to modernize and improve the grid to enhance resilience for both Maryland and DC customers.[51] Specifically, the project will: 1) upgrade three existing substations in DC and Maryland; 2) construct a new substation to serve areas projected to see high growth; and 3) build a new 10-mile underground transmission line to connect the substations and create a networked system. Pepco received approval for the Capital Grid Project in January 2020.[52] This project is estimated to provide many long-term benefits to customers within the District which rely exclusively on imported energy. These benefits include: 1) enhanced sevice, 2) stonger systems, 3) added capactiy, 4) economic support.

While both of these initiatives are still being implemented and while it may be too soon to determine impacts to grid resilience, the funding mechanism between the District and Pepco displays a unique way to structure and share resilient infrastructure costs between a public entity and a private utility and further displays how public-private partnerships with local utilities can enhance community resilience by identifying community reliability risk and creating targeted projects to mitigate risk.

Conclusion

Utilities will play a central role in creating communities that are resilient to climate change by strengthening their systems through investments and operational improvements. Both utility regulators and state and local policymakers can play important roles in guiding and supporting these utility actions. While each party will have different specific responsibilities and areas of focus, many commonalities exist: proactive action and assessment that relies on strategic planning and coordination across parties, collection and sharing of data and resources that can be used by utilities and their partners alike, and funding approval and sourcing that recognizes the need to act quickly and purposefully to prepare for current and future climate change conditions. Utilities will need to take significant action over the coming decades to address resilience to climate change, and the policymaker considerations described throughout this report can help ensure that this utility action is as efficient, effective, and equitable as possible.

[50] "DC PSC Chairman Releases Statement on the District of Columbia Power Line Undergrounding (DC PLUG) Initiative," Public Service Commission of the District of Columbia, https://dcpsc.org/CMSPages/GetFile.aspx?guid=54f06fd3-56de-42e3-ab89-36f6910d3367.

[51] "Capital Grid Project," Pepco, https://www.pepco.com/SmartEnergy/ReliabilityImprovements/Pages/CapitalGridProject.aspx.

[52] "Capital Grid Project," Public Service Commission of the District of Columbia, https://dcpsc.org/Newsroom/HotTopics/Capital-Grid-Project.aspx.

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