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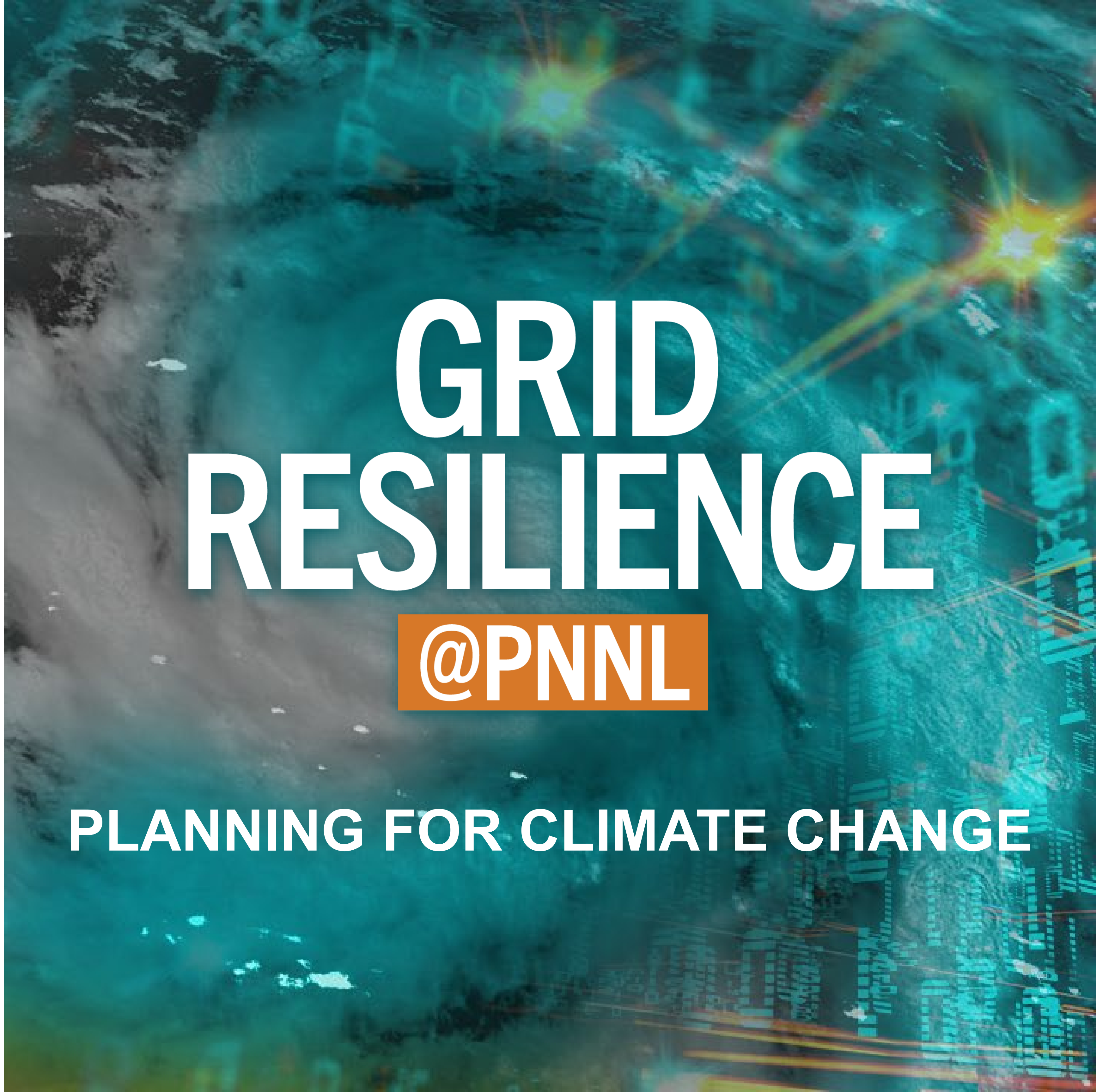
Emerging Best Practices in Planning for Climate Variability

Juliet Homer and Alan Cooke

August 28, 2023



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This work was funded by the U.S. Department of Energy's Water Power Technologies Office as part of the Integrated Water-Power Resilience Project.

The purpose of this work is to:

- Highlight developing issues, needs, and opportunities.
- Amplify emerging utility and regulatory best practices.
- Ultimately help increase and accelerate the climate resilience of the U.S. power system.

Agenda

- Juliet Homer
  - Resources
  - Forecasting with climate variability
  - Using climate data
  - Dealing with uncertainty
  - Emerging utility best practices
  - Data access
- Alan Cooke
  - Regulatory context
  - Asset planning
  - Emerging regulatory programs and approaches
  - Food for thought and closing remarks
  - Contacts and resources
- Q&A and discussion

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Reports

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PNNL-34304

Emerging Best Practices for Electric Utility Planning with Climate Variability

A Resource for Utilities and Regulators

May 2023

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Alan C. Cooke
Kamila Kazimierczuk
Rebecca Tapio
Julie Peacock
Abigail King

U.S. DEPARTMENT OF ENERGY | Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830

https://www.pnnl.gov/sites/default/files/media/file/Final%20Report%206_7_2023.pdf

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PNNL-30910

A Review of Water and Climate Change Analysis in Electric Utility Integrated Resource Planning

October 2021

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Kamila Kazimierczuk

U.S. DEPARTMENT OF ENERGY | Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830

https://epe.pnnl.gov/pdfs/Water_in_IRP_whitepaper_PNNL-30910.pdf

GRID MODERNIZATION LABORATORY CONSORTIUM U.S. Department of Energy

Considerations for Resilience Guidelines for Clean Energy Plans

For the Oregon Public Utility Commission and Oregon Electricity Stakeholders

September 2022

JS Homer
KM Boenker
AA Lippert
K Oikonomou
R Tapio
HJ Corsair

PNNL-33277

https://www.osti.gov/servlets/purl/1905600

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PNNL-34091

Grid Resilience to Extreme Events – Connecting Science to Investments and Policy

Workshop Report

April 2023

Juliet Homer
David Judi
Jason Fuller
Shannon Bates

U.S. DEPARTMENT OF ENERGY | Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830

https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-34091.pdf

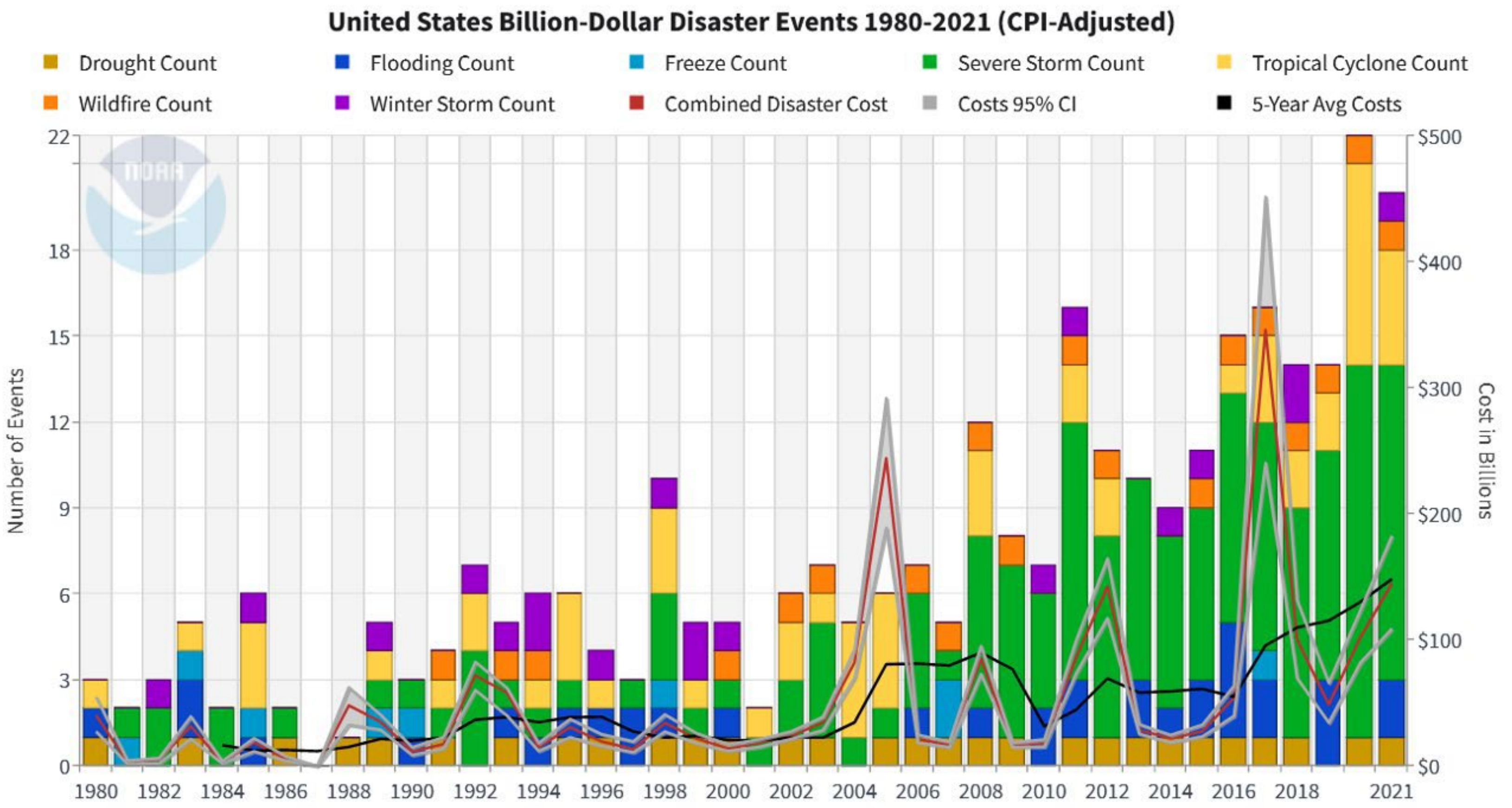
Climate


The New York Times

Heat Records Are Broken Around the Globe as Earth Warms, Fast

From north to south, temperatures are surging as greenhouse gases trap heat in the atmosphere and combine with effects from El Niño.

- Globally, the ten warmest years in the 143-year record have occurred since 2010 with **the last nine years (2014-2022) being the warmest on record** (NOAA).
- Grid impacts of a shifting climate vary greatly by region, and there is **significant uncertainty** associated with the degree to which grid impacts may occur.
- From 1980 to 2021, the U.S. experienced 323 weather and climate events in which the overall cost of the event reached or exceeded $1 billion.
- The **total costs of events** through July 11, 2022, adjusted to $2022, **exceeds $2.2 trillion** (NOAA).



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Climate change impacts to electric utilities

Key point: With the right information, utilities can now start making “climate-informed” investments, avoiding the need to replace assets later.

Climate Change Factor	Potential Impacts to Utility Assets
Extreme heat	Reduced equipment efficiency and a need to derate or update equipment
	Increased forced outage rates for thermal generators
	Need for modified or increased active cooling equipment
	Need to increase generation and the capacity of transmission and distribution assets to account for end-use load increases
	Worker safety issues and the need to change protocols to protect workers
Extreme cold	Need for increased vegetation management
	Need to weatherize electric system equipment and fuel supply chains
	Need to harden conductors to withstand increased ice loads
	Potential need to establish or support warming centers
Wildfires	Need for enhanced vegetation management
	Need to replace, modify, or underground equipment to prevent fires
	Need for enhanced equipment inspection and accelerated maintenance and repair programs to prevent utility equipment from causing wildfires
	Need for higher levels of situational awareness through equipment to measure weather and moisture conditions, and improved weather forecasting abilities
	Need for proactive power shutoffs and backup generators and battery storage systems for impacted communities
Extreme storms and sea level rise	Need for flood protection for low lying equipment or relocating assets out of floodplains
	Need to increase vegetation maintenance and harden infrastructure to protect it from wind and debris damage
Drought	Reduced water supply for hydropower or thermoelectric cooling
	Increased energy loads due to water pumping and irrigation
	Changes in other loads caused by drought impacts on agriculture and industry
	Increased probability of wildfire
Population migration	Locational shifts in energy demand and need to replace, rebuild, relocate and/or harden infrastructure to handle in-migration
	Loss of tax base and load due to out-migration

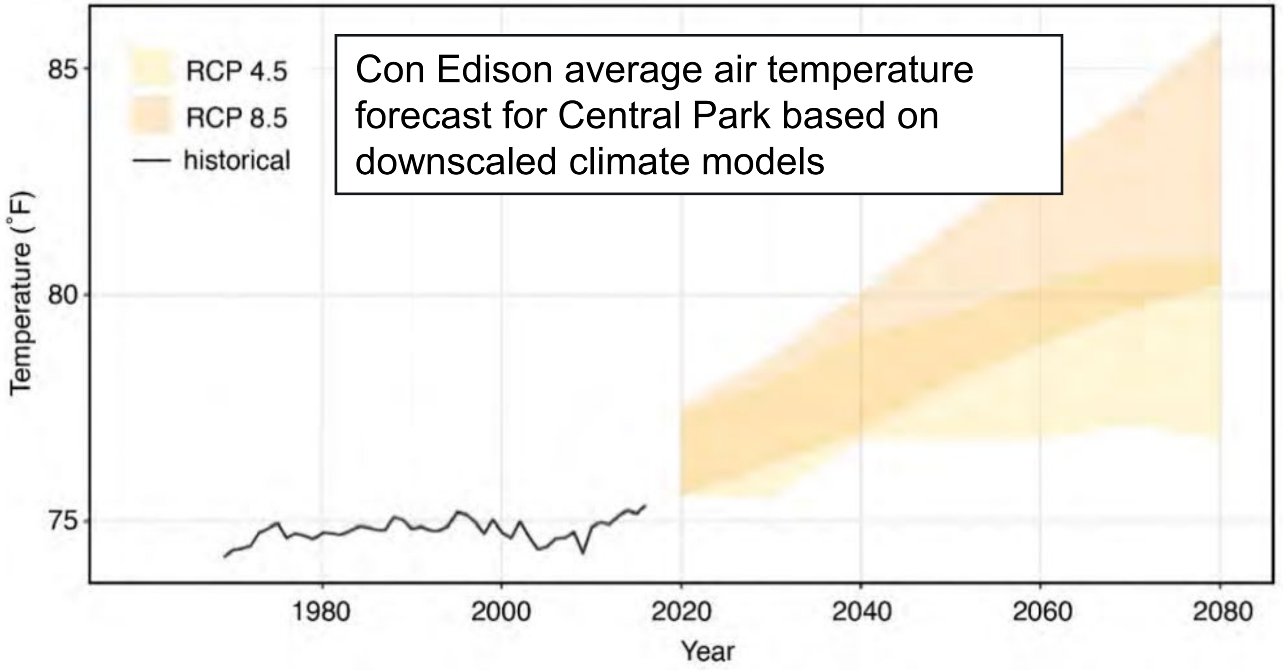
Source: PNNL 2023 Report Emerging Best Practices in Planning for Climate Variability

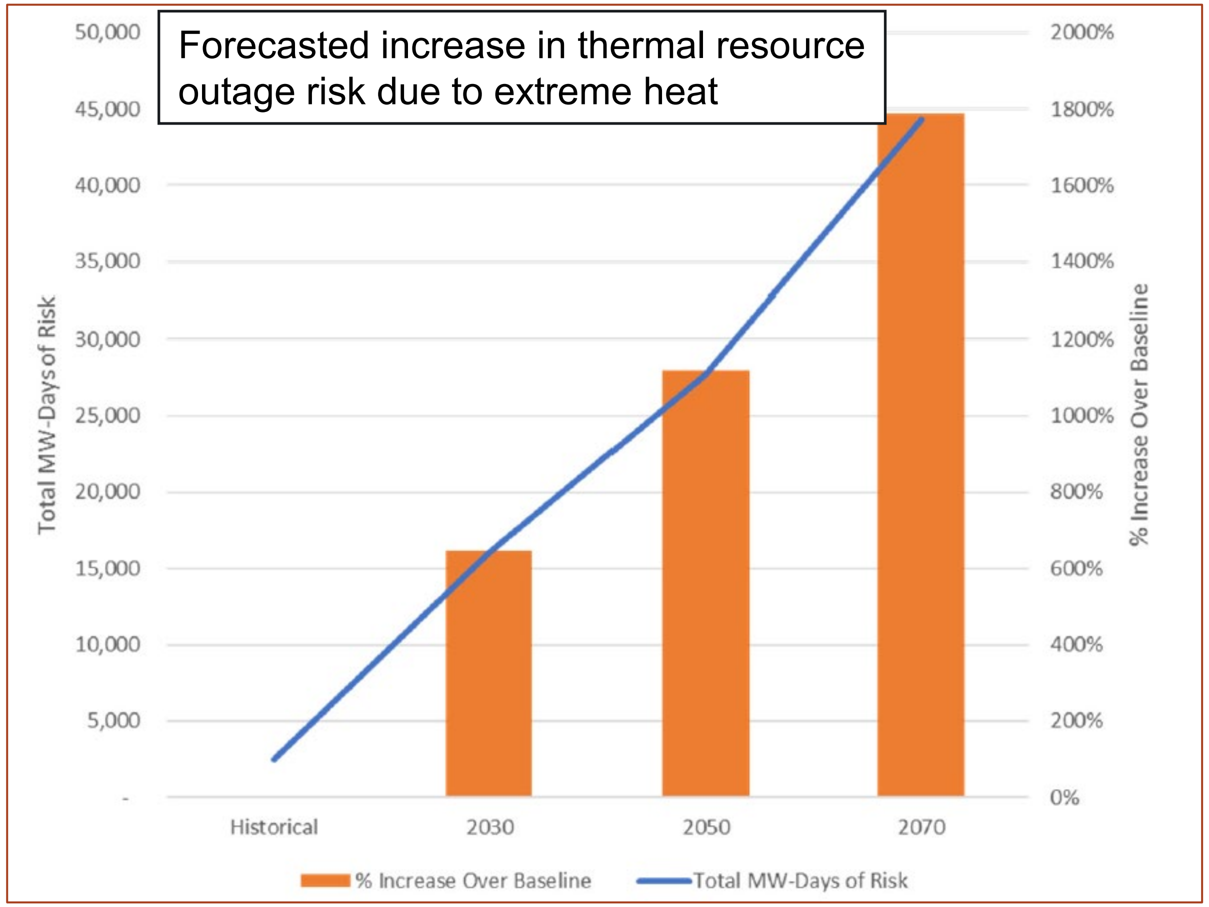
Forecasting with Climate Change

Key Point: The weather of the past is not necessarily representative of the weather of the future. If you're planning for the weather of the past, you may be planning for the wrong thing.

- Different approaches to the challenge of forecasting with climate change:
  - **Weighting recent years** (~15 years) more heavily in load and weather forecasts.
  - Applying **trends** rather than fixed averages for **the number and magnitude of heating-degree and cooling-degree days**.
  - Evaluating **trends in the availability of generation resources**.
  - Using adapted, or **downscaled**, results from global climate models as the basis for forecasts.

Con Edison. Climate Change Vulnerability Study. December 2019.

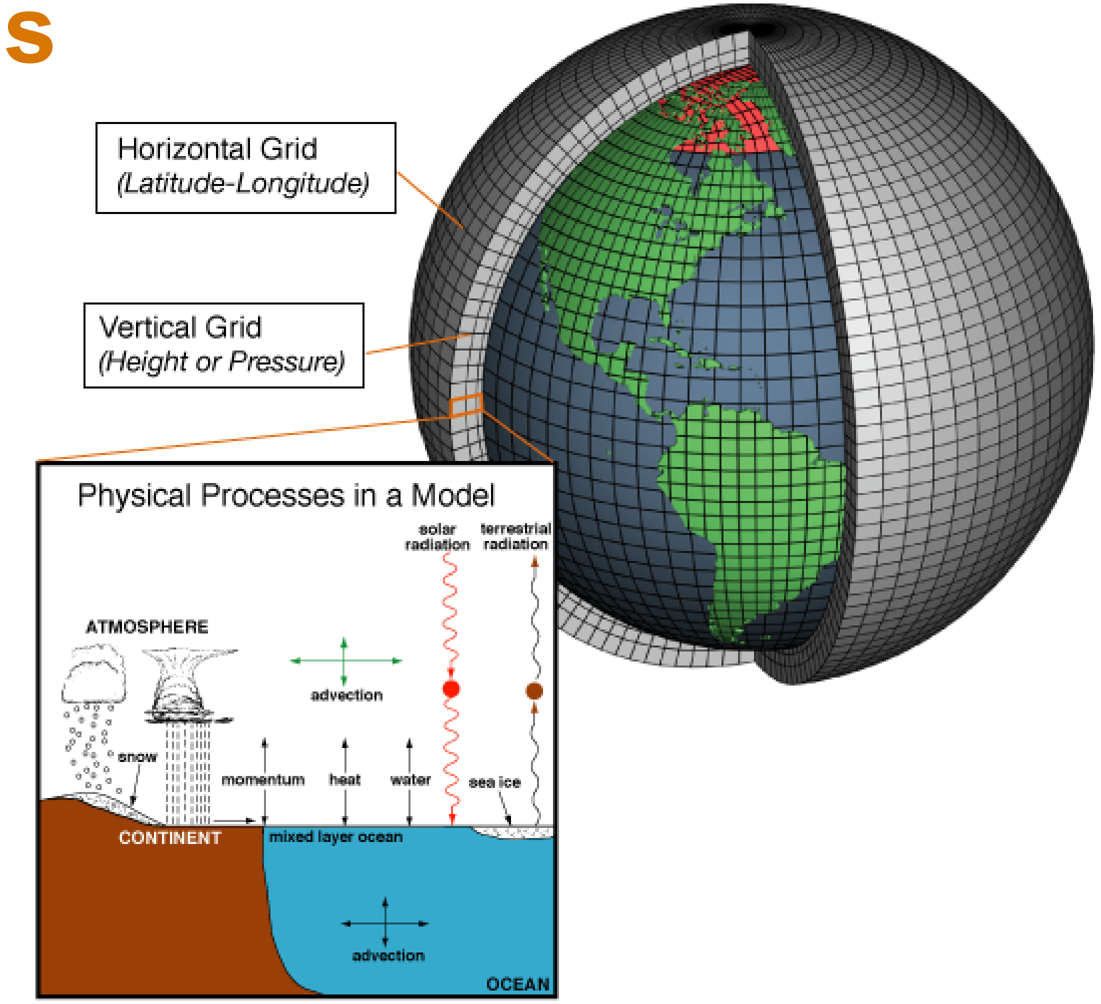




Southern California Edison . *Climate Change Vulnerability Assessment* May 2022.

Downscaling Climate Models

- Downscaling of climate models is a technique used to translate large-scale general circulation models (**GCMs**) into more localized results.
  - GCMs are complex models of the Earth's climate that consider the main components (land, oceans, atmosphere, and sea ice) and their interactions.
- Downscaling allows scientists to understand how climate change will impact local and regional climates.
- By modeling various representative concentration pathways (**RCP**) cases, scientists predict different climate futures based on emission trajectories and human behavior. **RCP 4.5 and 8.5 are common**.

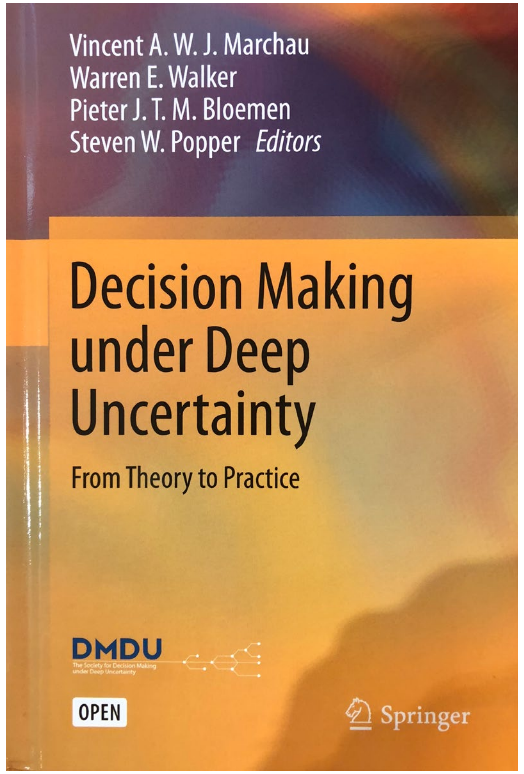


- Shared Socioeconomic Pathways (**SSPs**) are scenarios of different socioeconomic pathways and changes through the year 2100.
- The Coupled Model Intercomparison Project (**CMIP**) is a global coordinated modeling initiative designed to better understand climate change from various sources. SSPs have replaced RCPs in the latest round of CMIP models (**CMIP 6**).

Addressing uncertainty

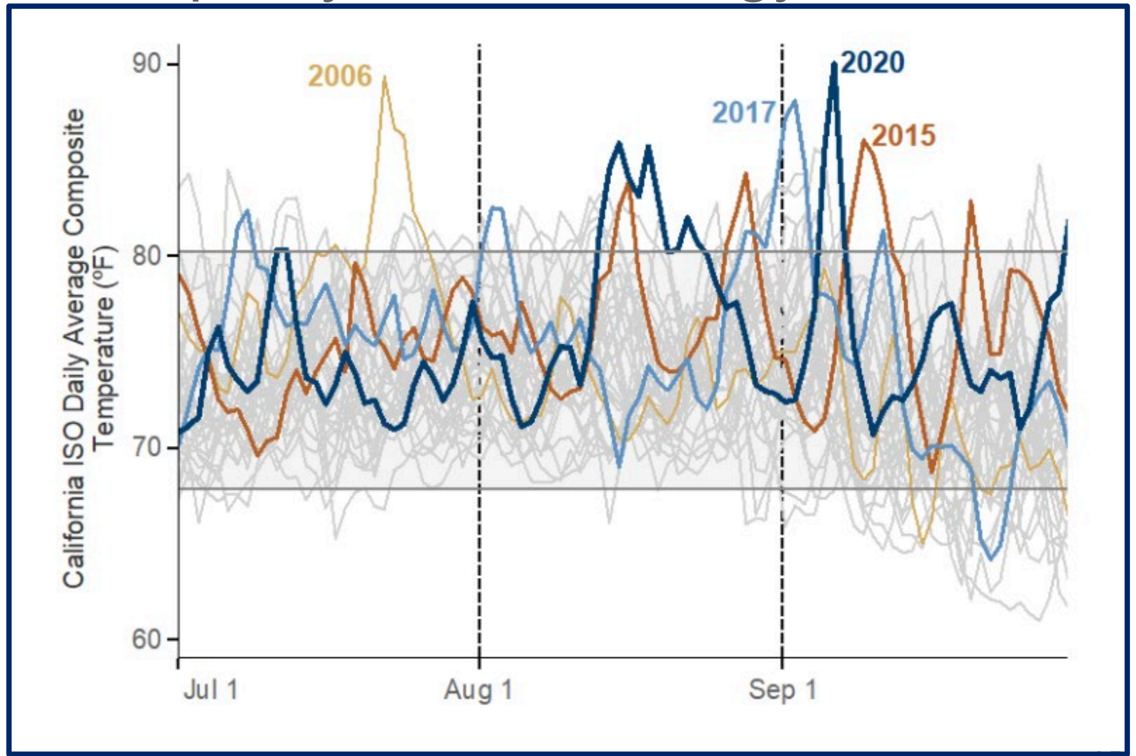
- Climate models are not a perfect representation of the Earth's climate, and it can be difficult to translate climate science into projections for utility planning.
- Alternative approaches, such as decision-making under deep uncertainty (**DMDU**), are growing in utilization.
  - Deep uncertainty occurs when parties cannot agree on the likelihood of alternative futures or how actions relate to consequences.
  - DMDU recognizes the principle of **non-stationarity**, which means that future conditions cannot be predicted based on the past, even if elements of those futures vary stochastically.
  - DMDU methods are based on a "monitor and adapt" paradigm rather than a "predict then act" paradigm and seek to build confidence in a decision rather than a model.
  - Adaptive pathway approaches are an example of a monitor and adapt strategy because utility actions shift as more information about climate change and external conditions is learned over time.

Key Point: In addition to considering climate models, it's important to focus on key system thresholds needed to maintain system stability and plan ways to maintain those under many different potential futures.



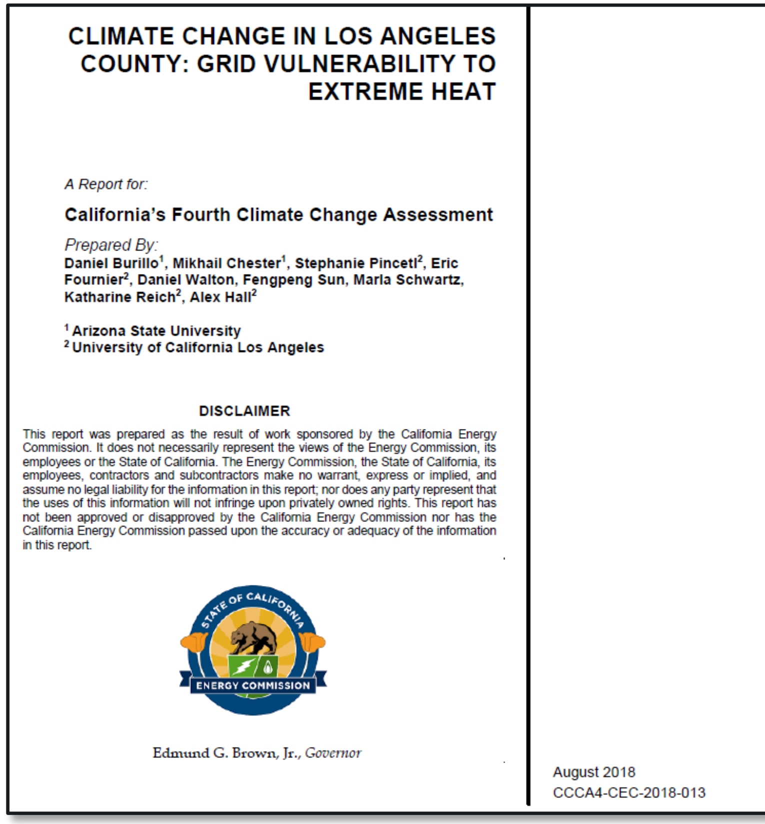
Emerging Best Practices in Resource Planning with Climate Change

1. **Use the latest downscaled climate data to** inform forecasted temperatures, water availability, and solar and wind resources.
    - Note: There are different downscaling approaches with associated pros and cons. Utilities should take care to select datasets that are appropriate for their needs.
2. **Consider multiple scenarios** based on downscaled climate models and observed trends, including those outside traditional history-based scenario analysis. Go beyond low, medium, and high scenario approaches and look at different policy and technology futures.
3. **Consider interregional impacts** of climate change on the grid, markets, and resource adequacy.
4. **Adjust resource adequacy approaches** to account for weather and resource uncertainty.
5. **Identify signposts or thresholds that signal needs for adaptive management decisions.** Track climate science and extreme weather events/trends and adapt planning criteria and operations accordingly.
6. Robust and diverse **stakeholder engagement**.



Integrated planning and risk assessment example #1: Southern California Edison/LA County

- California Energy Commission – [Climate Change in Los Angeles County: Grid Vulnerability to Extreme Heat].
- One of many such reports.
- Identifies future climate trends via downscaled climate data, especially future heat events.
- Estimates future loads.
- Identifies the capacity ratings of electrical assets in LA County, including the temperatures equipment is rated for.
- Identifies the impact on capacity if temperature ratings are exceeded.
  - All grid components expected to lose 2–20% of capacity by 2060.
  - Peak demand projected to increase between 0.2 and 6.5 GWh depending on population growth scenario, building efficiency, other factors, and warming case.
  - Gives area-specific implications, including estimates of the portion of the problem that could be solved by aggressive energy efficiency.



CLIMATE CHANGE IN LOS ANGELES COUNTY: GRID VULNERABILITY TO EXTREME HEAT

A Report for:

California's Fourth Climate Change Assessment

Prepared By:
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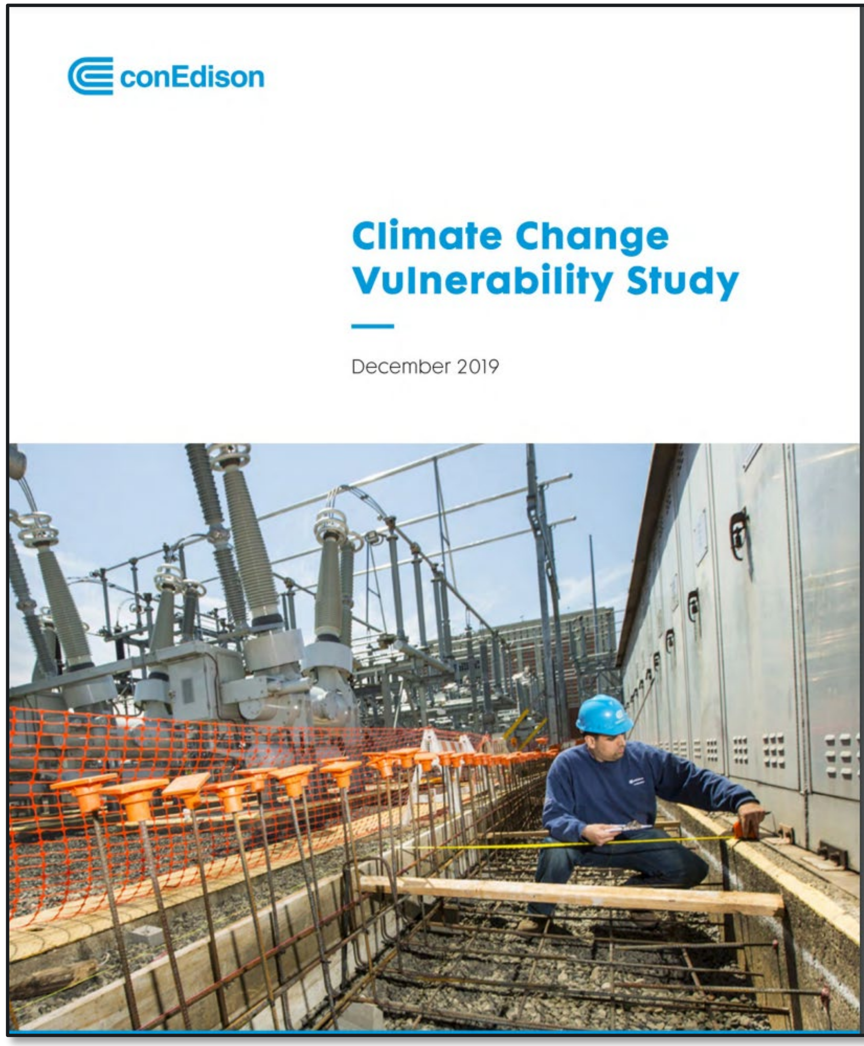
Edmund G. Brown, Jr., *Governor*

August 2018
CCCA4-CEC-2018-013

Integrated planning and risk assessment example #2: Con Edison

- Con Edison Climate Change Vulnerability Study.
- Response to several major weather events including Superstorm Sandy.
- Downscaled climate change data, identified portions of their system at risk due to:
  - Heat,
  - Severe precipitation events, and
  - Sea level rise.
- Identified new planning criteria for construction and hardening existing facilities.
- Led directly to a climate change implementation plan to implement hardening measures over the next 5, 10 and 20 years.
- Costs to date for planning = $1.35 million; requested another $4 million over the next 3 years to continue analyzing vulnerabilities and planning adaptation response.



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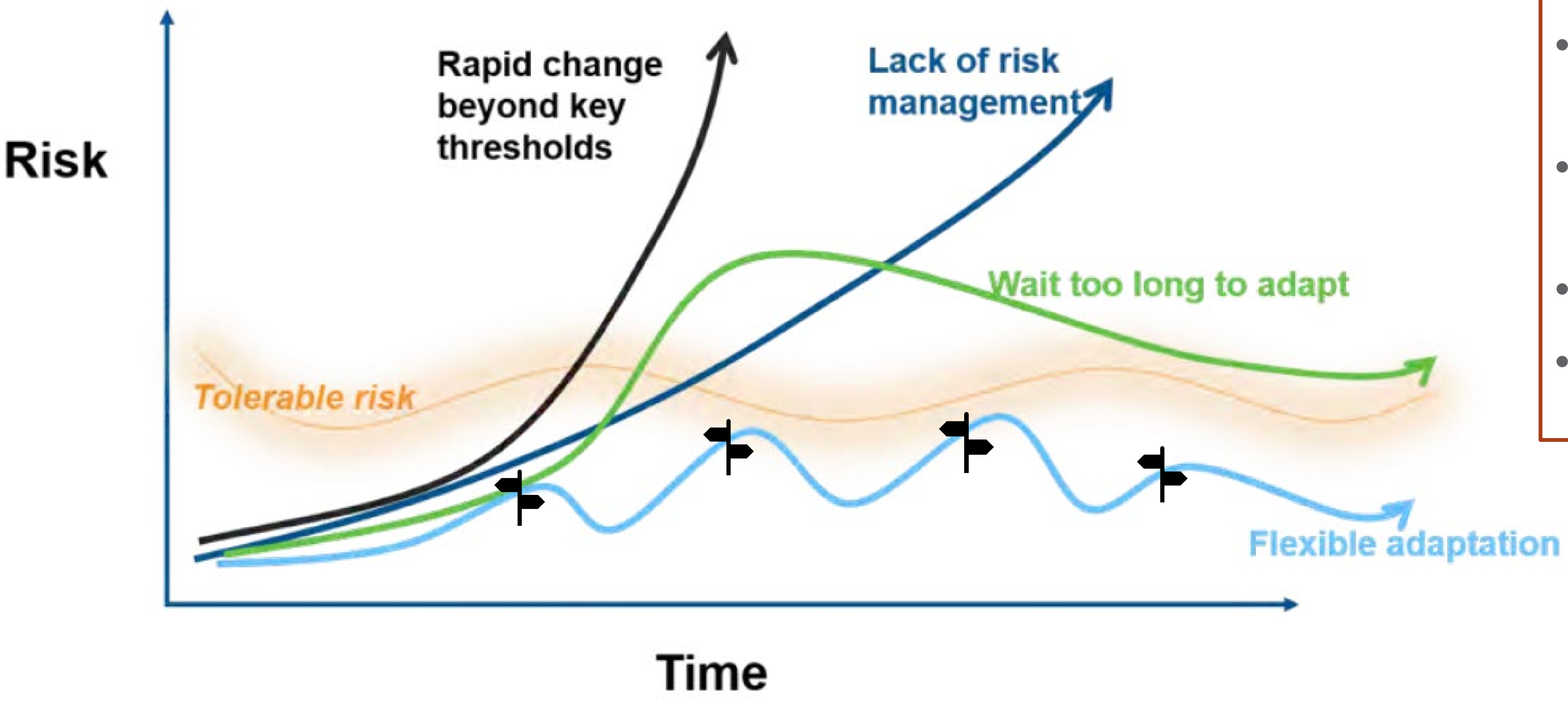
Con Edison Example

- Summer peak is expected to increase by 700 to 900 megawatts (MW) by 2050 due to temperature variations.
- Temperature increases and heat waves are expected to affect the distribution network reliability by 2030, absent adaptations.
- Due to increases in temperatures, the size of the cooling equipment in Con Edison's facilities may require an increase of up to 40 percent by 2040.
- An increase in temperature and heat index may exacerbate worker heat stress.

From Con Edison Climate Change Resilience and Adaptation – Summary of 2020 Activities. January 2021.

Key Areas	Summary of Process Updates	Key Findings
Load Forecasting	• Climate information will be included in future load forecasts for all commodities beginning in 2020. • Con Edison will incorporate anticipated temperature variable (TV)[9] increases into load forecasting, currently estimated at a 1-degree TV increase per decade beginning in 2030.	• The electric summer peak is expected to increase by 700 to 900 megawatts (MW) due to increased TV by 2050.
Load Relief	• Beginning in 2021, Con Edison will incorporate projected climate change-driven increases in load and reductions in power equipment ratings in the 10- and 20-year load relief plans.	• A relatively small impact on power transformers and network transformer ratings is expected due to ambient temperature rise between 2040 and 2050.
Reliability Planning	• Reliability modeling will use forward looking climate change-adjusted load forecasts and projected increases in TV. • In 2021, the Company will conduct a review of extreme event projections to determine whether additional model updates are warranted.	• Temperature increases and extended heat waves are expected to affect the reliability of distribution networks by 2030, absent adaptations.
Asset Management	• Con Edison processes will assess the extent to which expected future temperature changes impact ratings. • The Climate Change Planning and Design Guideline sets a flood design standard to account for increasing sea level rise, which applies to the electric, gas, and steam systems.	• The sea level projection exceeds the current design criterion of one foot of sea level rise by 2040.
Facility Energy Systems Planning	• Con Edison is updating designs to provide more flexibility for modifications during heating, ventilation, and air conditioning system replacement.	• Due to increases in temperature, the size of the cooling equipment in Con Edison's facilities may require an increase of up to 40% by 2040.
Emergency Response Activations	• Discussions are underway on how to incorporate heat, flooding, and precipitation projections into the weather and impact forecast model used to establish the Company's emergency response preparation to weather events. • The Company will plan for drills and exercises based on projected pathway criteria.	• Projected climate pathways could impact future weather and storm impact forecasts. • The Company will continue reviewing ways to incorporate climate change into a forward-looking model.
Worker Safety	• Con Edison will monitor climate change for impacts on worker safety. In 2022, the Company will consider whether additional heat stress protocols for climate change adaptation are warranted.	• An increase in temperature and heat index may exacerbate worker heat stress.

Flexible and adaptive approach

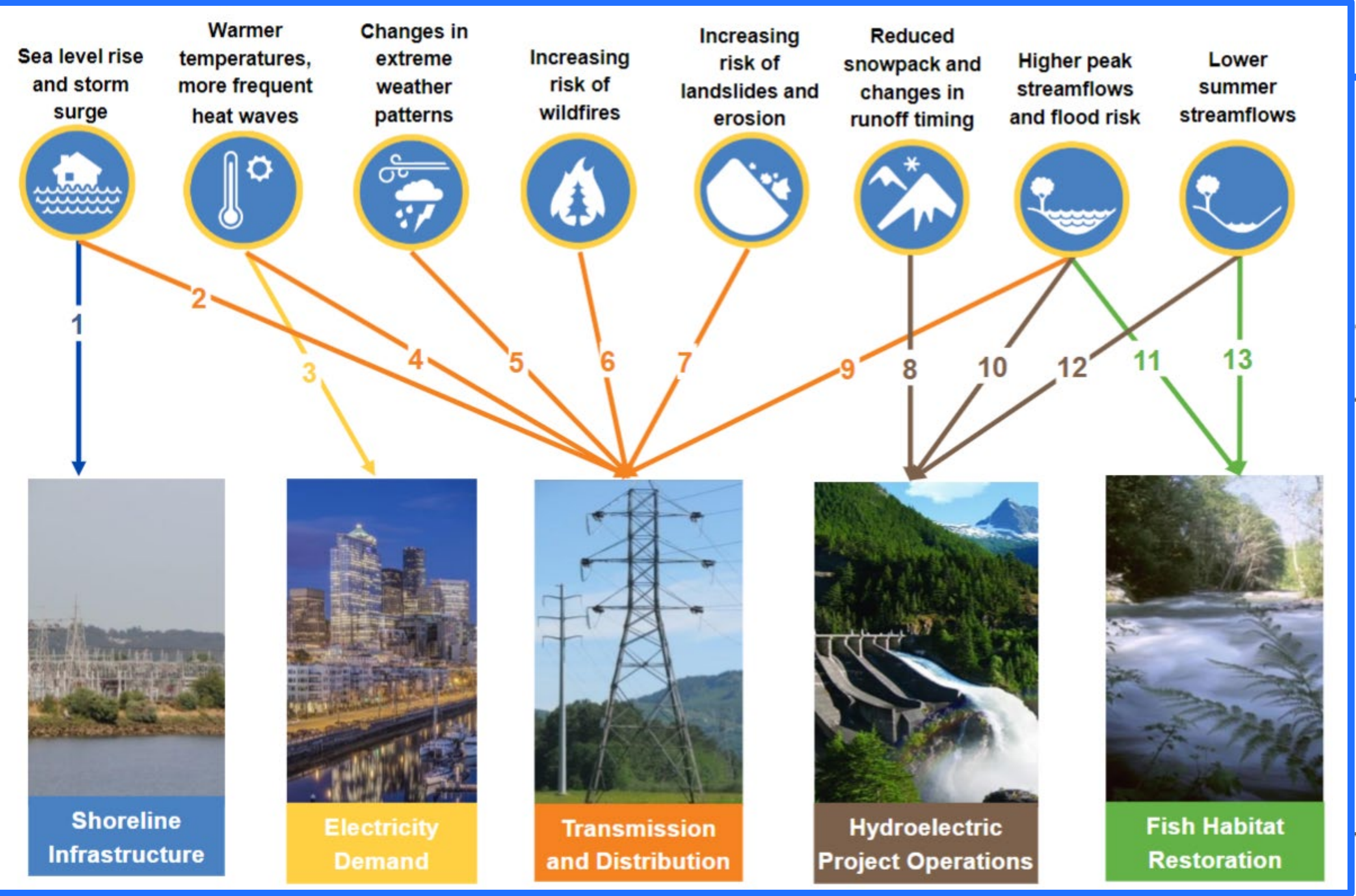


Con Ed signpost categories:

- Observed climate phenomenon
- Updated climate projections
- Climate impacts
- Policy, societal and economic conditions

Adapted from Con Edison Climate Change Vulnerability Study. December 2019 and Rosenzweig & Solecki, 2014.

Seattle City Light Example



Utility Function	Impacts Caused by Climate Change*	Time	Vulnerability: Exposure	Vulnerability: Sensitivity	Vulnerability: Capacity to Adapt	Potential Magnitude** of Impact to: Financial Cost	Safety	Reliability	Environmental Responsibility	Ref. Pages
Coastal properties	Tidal flooding due to higher storm surge and sea level rise	2030	○	● (yellow)	● (red)	Low	–	–	Low	18-24
		2050	● (yellow)			Mod	–	–	Low	
Transmission and distribution	Tidal flooding and salt water corrosion due to higher storm surge and sea level rise	2030	○	○	● (yellow)	Low	–	Low	–	18-24
		2050	● (yellow)			Low	–	Low	–	
	Reduced transmission capacity due to warmer temperatures	2030	● (yellow)	○	○	Low	–	Low	–	34-39
		2050	● (yellow)			Low	–	Low	–	
	More frequent outages and damage to transmission and distribution equipment due to changes in extreme weather	2030	○	● (yellow)	● (yellow)	Low	Low	Low	–	40-46
		2050	○			Low	Low	Low	–	
	More damage and interruptions of transmission and generation due to wildfire risk	2030	● (yellow)	● (red)	● (yellow)	High	High	Med	–	47-53
		2050	● (red)			High	High	Med	–	
	More damage to transmission lines and access roads due to landslide risk	2030	● (yellow)	● (yellow)	● (yellow)	Med	Low	Med	–	54-58
		2050	● (yellow)			Med	Low	Med	–	
	More damage and reduced access to transmission lines due to more frequent river flooding and erosion	2030	● (yellow)	● (yellow)	● (red)	Med	–	Low	–	71-74
		2050	● (red)			High	–	Low	–	
Energy Demand	Reduced electricity demand for heating in winter due to warmer temperatures	2030	● (yellow)	● (yellow)	● (red)	Med	–	Low	–	25-33
		2050	● (red)			High	–	Low	–	
	Increased electricity demand for cooling in summer due to warmer temperatures	2030	○	○	● (red)	Low	–	Low	–	25-33
		2050	● (yellow)			Med	–	Med	–	

*The impacts are those caused by climate change in addition to historical conditions; most existing hazards (such as windstorms) will continue.
**Magnitude refers to the average event or normal condition for the timeframe, not the worst possible year or event that could occur.

https://www.seattle.gov/light/enviro/docs/Seattle_City_Light_Climate_Change_Vulnerability_Assessment_and_Adaptation_Plan.pdf

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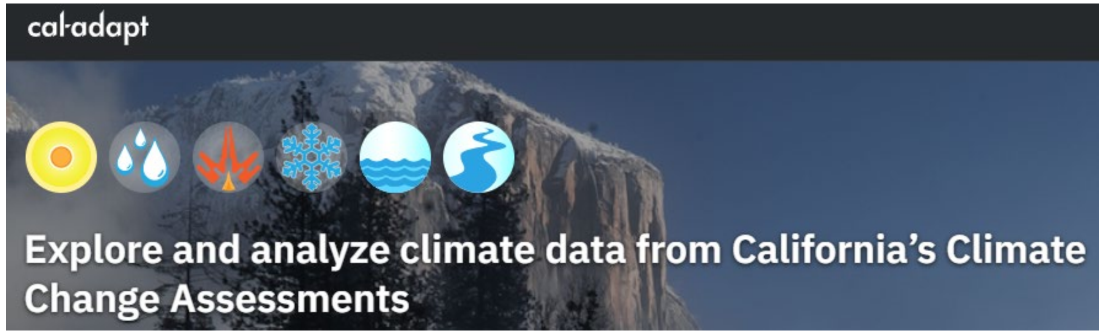
Seattle City Light Example (continued)

	Potential Adaptation Actions
Shoreline Infrastructure	Make **sea level rise and storm surge spatial information** available to all divisions of the utility.
	Consider a utility policy to identify future impacts of tidal flooding to potentially impacted **capital improvements**.
Electricity Demand	**Expand analysis** of the relationship between warming temperatures, season base and peak load, and air conditioner use.
	Identify **co-benefits of energy efficiency** to reduce electricity demand for summer cooling.
	Address potential for **demand response** to reduce peak commercial loads for areas with constrained distribution systems.
Transmission and distribution	Monitor and consider replacing **equipment sensitive to corrosion** from salt water in areas subject to tidal flooding.
	Monitor failures and **damage to underground cables** due to drier soils and consider alternative fill materials.
	Expand the use of **Outage Management Systems (OMS)** to quantify trends in extreme weather on outages.
	Increase the **capacity of employees** to prepare for and respond to increasing wildfire risk.
	Collaborate with adjacent landowners to **reduce flammable vegetation** and wildfire hazards along transmission lines.
	Work with state agencies and academic institutions to **map landslide risk** along transmission lines.
	Where needed, **upgrade transmission infrastructure** to be resilient to higher peak flows and flood hazards.
Hydroelectric operations	Update and expand **analyses on how to adjust operations** to account for reduced snowpack and changing seasonal flows.
	Collaborate with other city utilities on modified dam operations.
	Consider **diversifying power resources** by increasing non-hydro renewable energy sources with complementary generation profiles.
Fish Habitat Restoration	Consider changed water flows in prioritizing acquisitions of **habitat mitigation lands.**
	Focus objectives and **design of restoration projects** on ameliorating impacts of changed stream flows and temperatures.

https://www.seattle.gov/light/enviro/docs/Seattle_City_Light_Climate_Change_Vulnerability_Assessment_and_Adaptation_Plan.pdf

Data



- Downscaling global climate models can be **time-consuming and expensive.**
- Many utilities are **developing datasets in partnership** with government and academic organizations.
- **Different models can provide different results**, and there are different downscaling approaches with pros and cons.
- Utilities and regulators can **work with climate scientists or "climate translators" to** help them navigate the uncertainty and myriad of climate and weather data and information available based on threats and specific decisions that need to be made.
- In California, state organizations regularly conduct **statewide climate change assessments**. They develop granular (6 km by 6 km) climate change data for use by all utilities, municipalities, and other entities through a web portal called **Cal-Adapt.**
- Other regional and national-level datasets exist that can be informative to electric utilities, including the [Pacific Northwest National Laboratory (PNNL) Climate Research Portal.]

- **Seattle City Light** teams with University of Idaho to downscale GCMs & University of Washington to project streamflow for hydro
- **Con Edison** worked with ICF, Columbia University, and Jupiter Intelligence
- **Puget Sound Energy** and **Tacoma Power** worked with the Northwest Power and Conservation Council, Bonneville Power Administration, the U.S. Army Corps of Engineers, and the Bureau of Reclamation
- **Southern California Edison** used information developed and made available through Cal-Adapt

Alan Cooke, PNNL

Regulatory Perspective Context

Context for Regulatory Perspective

Photo by Noah Boyer on Unsplash

- Addressing climate change impacts on utilities, and utilities’ responses, falls within regulators’ purview given the impacts on:
  - Reliability
  - Cost of service
  - Safety –worker and public safety (e.g., downed power lines/wildfire ignition risk)
  - Equity issues arising out of reliability, cost and safety issues
- Regulatory commissions are taking steps to require utilities to adapt systems for a changing climate – to withstand severe weather events and/or improve resiliency.

Asset planning and operations for climate adaptation

- Many utility assets are designed for specific temperature ranges.
  - Temperatures above or below the specified max or min can lead to capacity derating, damage, and failure, and increased maintenance requirements.
  - Existing equipment (transformers, conductors, etc.) may not be designed for temperatures being experienced in the future (or today in some cases like our recent heat dome events).
- Higher temperatures also correspond to higher loads which can present overload issues for existing assets.
- In some cases, utility assets now find themselves located in FEMA floodplains based on updated flood mapping.
- Layers of utility assumptions need to be reevaluated. Utilities have traditionally used guidelines and rules of thumb for asset planning and operations, developed and adjusted over time based on the history of how things have operated.
- Reevaluation should be broad – assets and operations (e.g., vegetation management).
- Regulators can encourage utilities to reevaluate assumptions and ask for regular updates.

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Best practice regulatory programs addressing climate issues

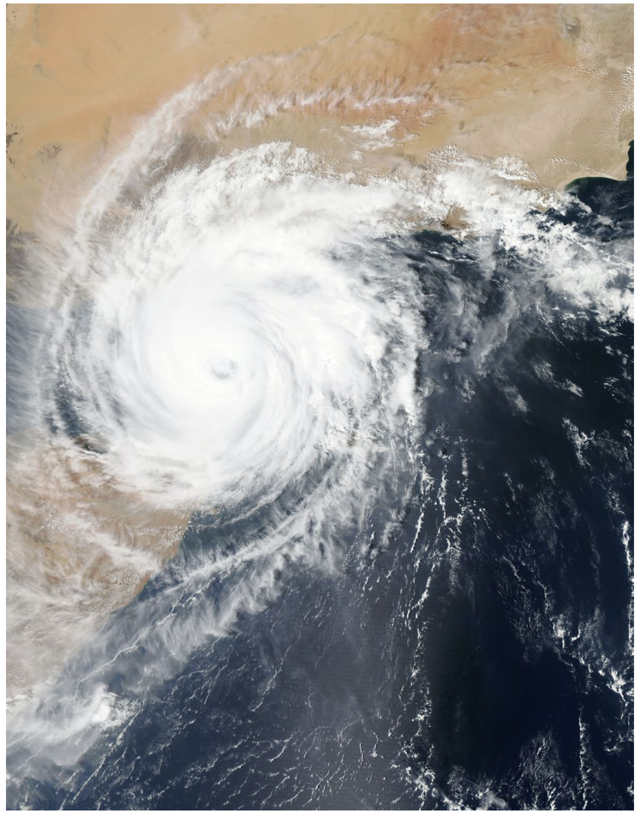

Photo by NASA on Unsplash

- Resilience / storm hardening proceedings
  - Response to derechos, nor'easters, and hurricanes.
  - Can have a definable end point.
  - Can include mitigating and adapting measures.
- Addressing specific risks
  - Wildfire Mitigation Plans – ongoing plan assessing fire ignition risks and adaptations; periodic updates.
  - Storm Protection Plans – ongoing plan addressing a specific list of measures to increase storm resilience; periodic updates.
- Comprehensive climate vulnerability assessments
  - Based on downscaled climate change projections.
  - Comprehensive assessment of climate risks to all assets and operations.
  - Periodic and ongoing.
- Initiation of process to analyze climate risks can be driven by utilities, regulators, or legislation.

State Requirements and Resilience Actions Tied to Cost Recovery

Climate-Related Process	California	Connecticut	D.C.	Florida	Hawaii	Louisiana	Maryland	Massachusetts	Michigan	Nevada	New Hampshire	New Jersey	New York	North Carolina	Oklahoma	Oregon	Pennsylvania	Rhode Island	Texas	Utah	Washington
State-level planning requirements																					
Requirement for climate vulnerability assessment and mitigation plans	●	●											●								
Requirement for storm management plans				●																	
Requirement for wildfire mitigation plan[1]	●									●						●				●	○
Requirement to consider climate change in distribution system planning									○												
Settlement agreement requires climate vulnerability assessment														●							
Resilience actions tied to cost recovery																					
Grid hardening or storm management actions tied to cost recovery surcharge	●	●	●		●	●	●	●			●	●	●	○	●		●	●	●		

● is used to indicate the statutory or legislative requirement exists, or utilities voluntarily developed the plans indicated.
○ is used to indicate that dockets are open in which the objective would apply.
[1]States apply several names, e.g., resource protection plans, but wildfire mitigation is a major part of such alternative plans.

Source: Table is from the PNNL report, Emerging Best Practices for Electric Utility Planning with Climate Variability, page 45.

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Role for Regulators, part 1

- Establish ***clear goals, expectations, and metrics*** including identifying risks utilities should plan for and data sets to use. Ask the questions!
  - Can help prioritize climate change investments and allay concerns about cost recovery.
  - Community engagement plans can be part of the requirements.
- Require utilities to ***systematically review risks to assets & prioritize risks.***
  - Can focus investments on the greatest risk areas.
  - Can identify climate-adapted investments that can be made synergistically with ongoing projects, reducing the cost of achieving increased resilience.
  - Can identify operational strategies such as enhanced tree trimming.
- Ultimately, ***consider climate readiness actions in prudence reviews***
  - Climate projections have been “reasonably available” for some time, and in many cases extreme weather trends are starting to emerge.
  - If regulatory bodies set clear goals and expectations, investments not vetted through a climate adaptation process could be at some risk in a future prudence review.

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Role for Regulators, part 2

- Consider how partnerships and additional funding resources can be leveraged.
- Consider the how best to allow climate adaptation costs to be recovered. Some utilities have questioned whether new incentive cost recovery options are needed to incentivize proactive resilience investments to address long-term (2050) risks.
- Consider the level of prescriptiveness to use when establishing regulatory requirements for addressing the impacts of climate change (e.g., specifying representative pathways for use in analyses, or not).

Table 5.3. Excerpts from the CPUC Guidelines to California Electric Utilities for the Climate Adaptation and Vulnerability Assessments (CPUC 2019, 2020)

	Excerpts from the CPUC Guidelines
Data Guidance	Utilities shall **use the same three climate scenarios and projections** used in the most recent California Statewide Climate Change Assessment. If a new assessment becomes available, the utilities shall **align with the new scenarios** and projections. For any other climate variables or climate trend datasets, utilities shall **prioritize peer-reviewed methodologies** over those not peer-reviewed.
	Utilities shall **use Representative Concentration Pathway 8.5** for a business-as-usual case.
Addressing Disadvantaged Vulnerable Communities	A **definition**[6] of disadvantaged vulnerable communities (DVCs) was provided by the CPUC. Utilities shall **place maps on their websites** illustrating the locations of DVCs.
	A definition[7] of adaptive capacity was provided. Utilities shall **consult with DVCs** and consider their advice in determining **levels of adaptive capacity**. Vulnerability assessments must include an analysis of **how investor-owned utilities (IOUs) promote equity** in DVCs based on the communities' adaptive capacity.
	Utilities are required to **file Community Engagement Plans** every four years, and one year before the filing of the Vulnerability assessment. Utilities must meet with community-based organizations and DVCs in developing their plans.

	Excerpts from the CPUC Guidelines
Vulnerability Assessment Requirements	Plans shall be submitted **every four years** and address the **next 20-30 years** primarily, but also address the 10-20 year and 30-50 year time frames.
	At a minimum, the assessment must **consider the following criteria**: • Temperature • Sea level • Variations in precipitation, including snowpack, extreme precipitation events, long-term precipitation trends, droughts, subsidence • Wildfire • Cascading impacts
	Utilities must use the Department of Water Resources' **two-step vulnerability assessment methodology** that 1) combines exposure and sensitivity to determine risk, and 2) combines risk and adaptive capacity to determine vulnerability.
	Consider and identify **climate risks to IOU operations and service** as well as to utility assets over which the IOUs have direct control. Assessment should also consider risks to facilities the utility contracts with.
	Plans should consider an **array of options** for dealing with vulnerabilities, ranging from easy fixes to more complicated, longer-term mitigations. Green and sustainable remedies should also be considered.

See decisions D.20-08-046 and D.19-10-054.

Opportunities for cost savings while adapting for climate change impacts

- Climate data partnerships to share costs of climate data.
  - Downscaling can be expensive, and multi-utility or agency collaborations (e.g., Joint Utilities in New York, NYSERDA, NY Dept of Public Service staff; Cal-Adapt) can share this cost.
  - Provides consistent data and data quality.
  - Supports entities that are less able to afford it on their own.
- Partnerships to share costs when roads are dug up.
  - Utilities, transportation departments and water utilities can share expenses whenever someone must dig up roadways.
  - Washington, D.C. and Pepco undergrounding project is an example where overhead wires are being undergrounded.
- Leveraging utility’s construction to upgrade for climate change. A best practice is to review all planned projects to determine if upgrading for future conditions is warranted (e.g. Con Edison).

Key point: Climate data development partnerships offer many benefits beyond simple cost savings.

Other rate concerns regulators may need to address

- **Key point**: Climate models provide projections, not exact and observable data. Engaged stakeholders strengthen the process of identifying climate risks, mitigations, and associated benefits and spending levels.

- Climate adaptation provides benefits to customers and to the public in terms of increased reliability / resilience.
- Ratemaking practice includes procedures to minimize inter-generational transfers, so some people may object to upgrading facilities today for the climate of the future. However:
  - Climate projections are not perfect.
  - The Pacific Northwest heat dome of 2021 was anticipated as a possibility by climate models, but according to some scientists it was not expected until after 2030.
- Climate vulnerability assessments can be expensive, and utilities may want some assurance of cost recovery.
- Vulnerability analyses and adaptations should explicitly include disadvantaged communities to ensure they benefit equitably.

Food for thought to leave you with

- Is there a role for the federal government?
  - Coordination and support?
  - Other support for state activities?

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Closing remarks

- The weather of the past may not be representative of the **weather of the future**.
- **Downscaled global climate models** can provide directional guidance for planning for the weather of the future, but no model is perfect.
- Planners can lean on climate science, observed trends, **robust and flexible adaptive approaches,** and least-regrets approaches relative to **critical system thresholds.**
- **Smaller utilities can learn from larger and more-resourced utilities** and leverage publicly available data sets like Cal-Adapt.
- Each **state and utility is different** and will have its own needs and priorities.
- **Regulators play an essential role** in establishing clear goals, expectations, and metrics.
- Extensive and diverse **stakeholder engagement** can lead to more robust and equitable outcomes.
- The **challenges of climate change require working across traditional silos** and organizations and developing creative solutions that leverage different funding sources, synergistic investments, and operational collaboration.

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Contacts and resources

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- Reports:
  - Emerging Best Practices in Planning for Climate Variability
  - A Review of Water and Climate Change Analysis in Integrated Resource Plans
  - Considerations for Resilience Guidelines in Clean Energy Plans
  - Grid Resilience to Extreme Events: Connecting Science to Investments and Policy

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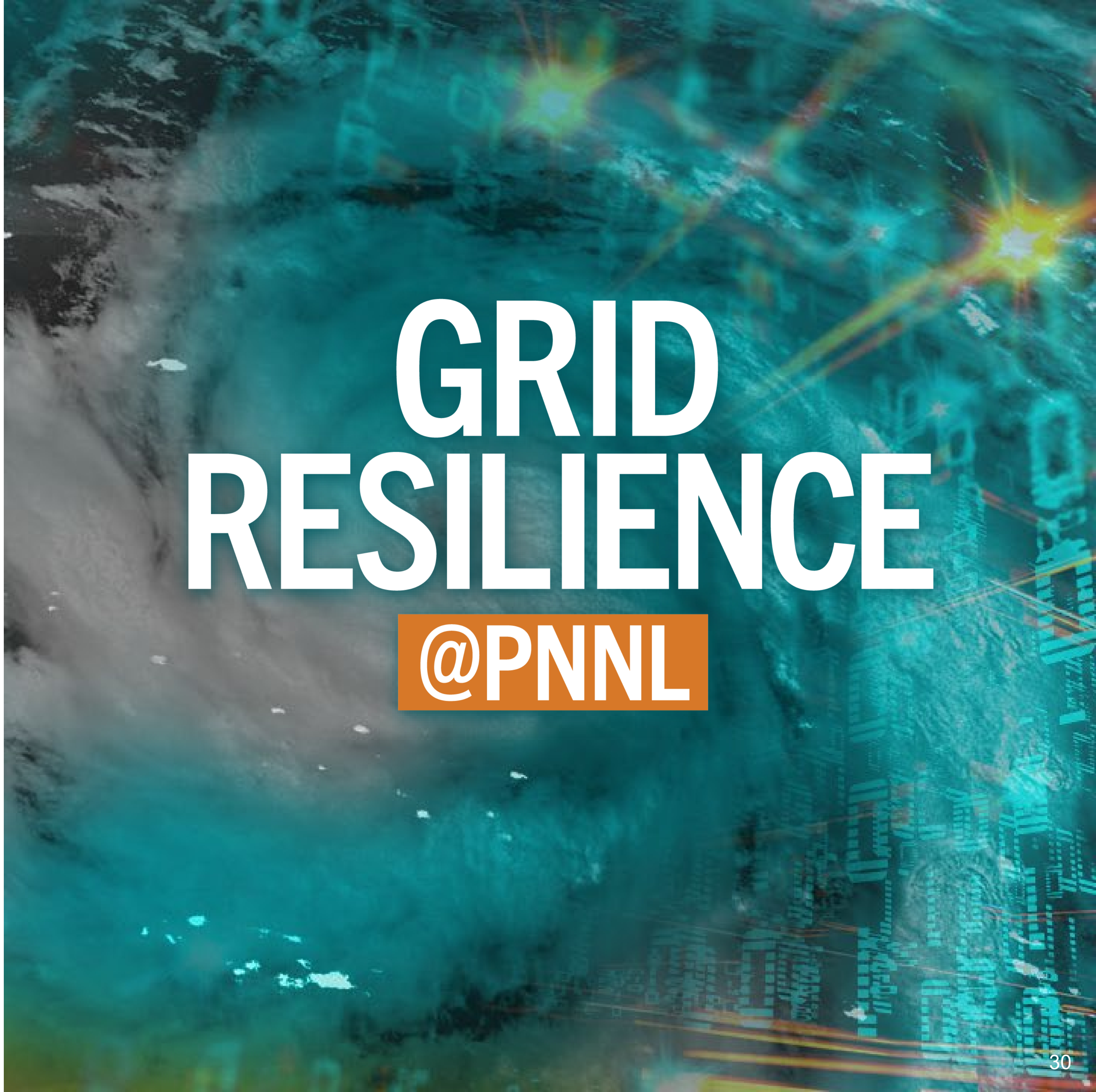
Thank you



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