Resilience and Resource Adequacy

Juliet Homer

December 7, 2023

NARUC Bulk Power System Learning Module

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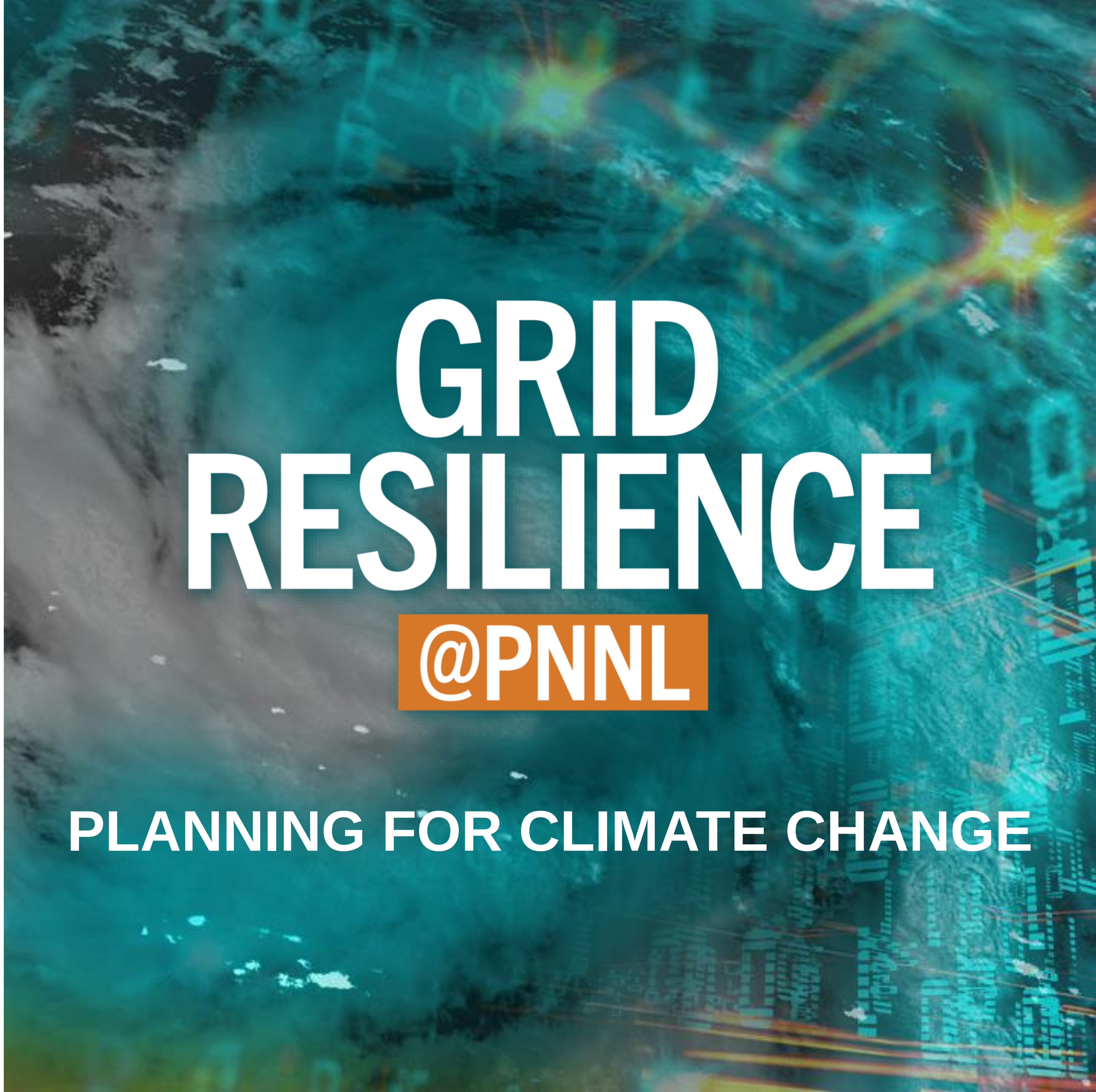


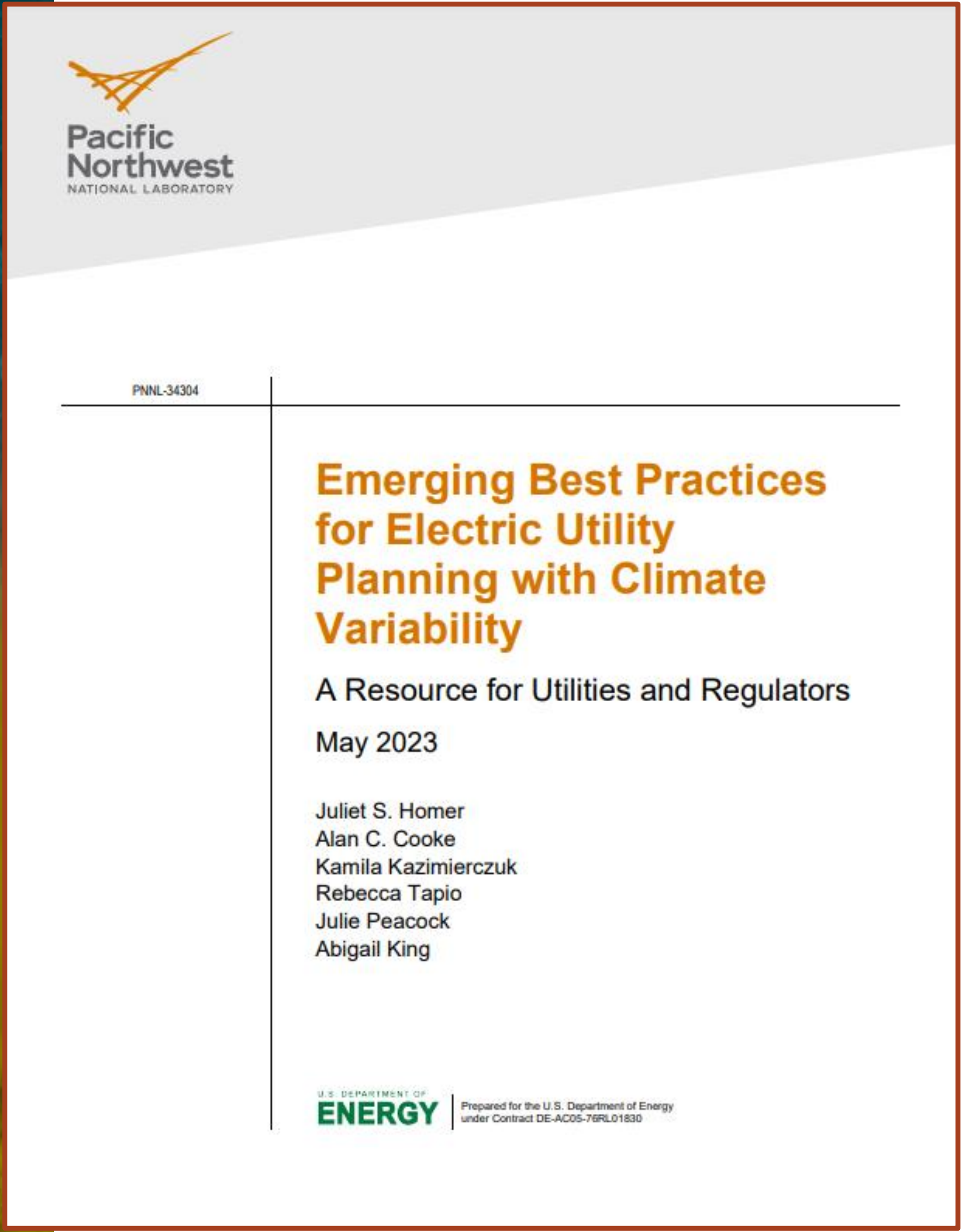
Agenda

- Background
- Climate change and resource planning
- Examples
- Data
- Roles for regulators

WATER + POWER
RESILIENCE

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy
WATER POWER TECHNOLOGIES OFFICE

Reports



PNNL-34304

Emerging Best Practices for Electric Utility Planning with Climate Variability

A Resource for Utilities and Regulators

May 2023

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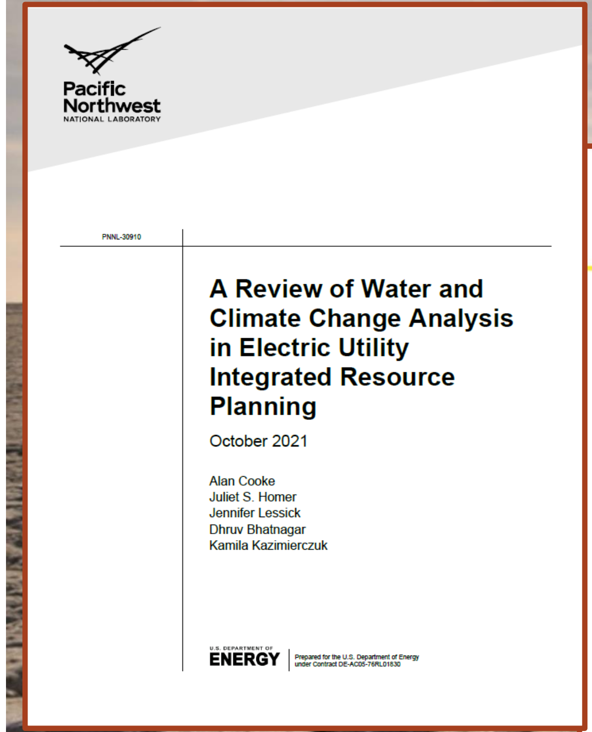
U.S. DEPARTMENT OF ENERGY | Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830

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



PNNL-30910

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

October 2021

Alan Cooke
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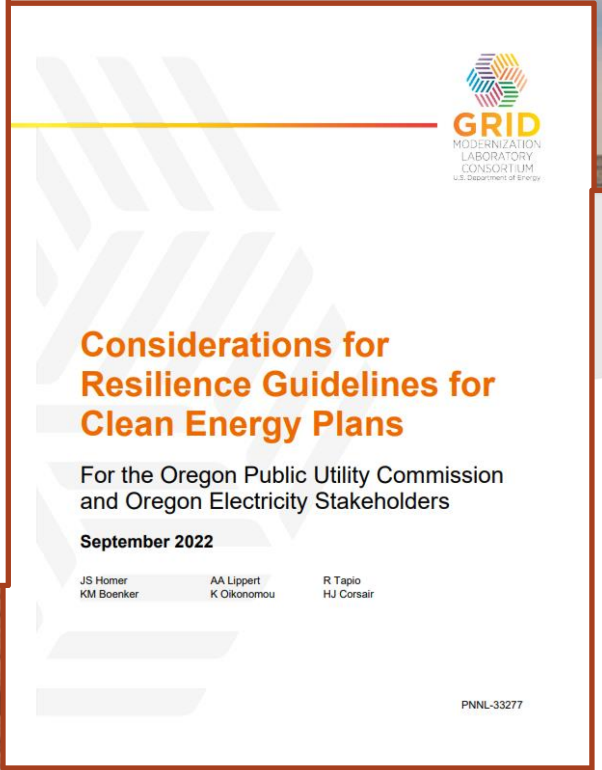
Kamila Kazimierczuk

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

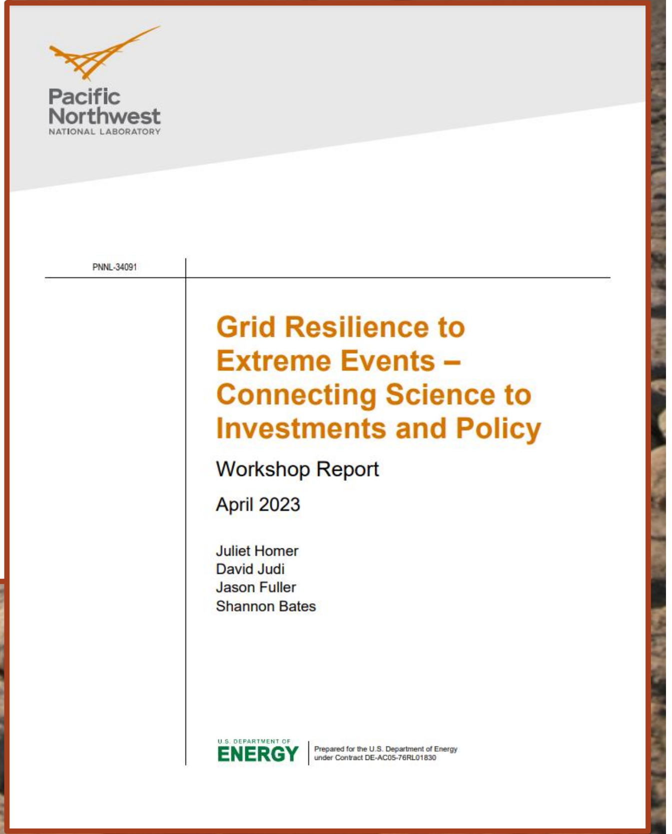
For the Oregon Public Utility Commission and Oregon Electricity Stakeholders

September 2022

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

PNNL-33277

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



PNNL-34091

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

Workshop Report

April 2023

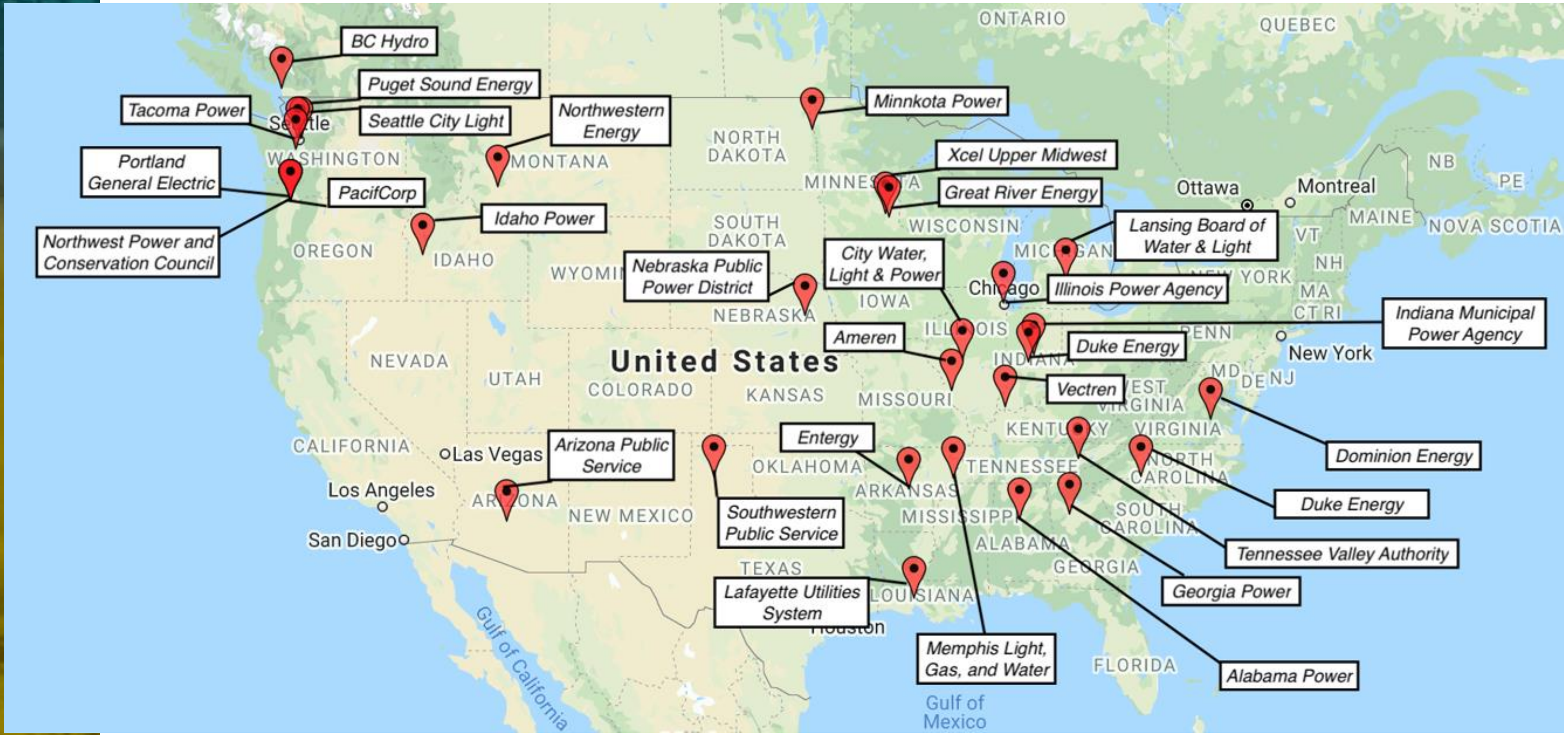
Juliet Homer
David Judi
Jason Fuller
Shannon Bates

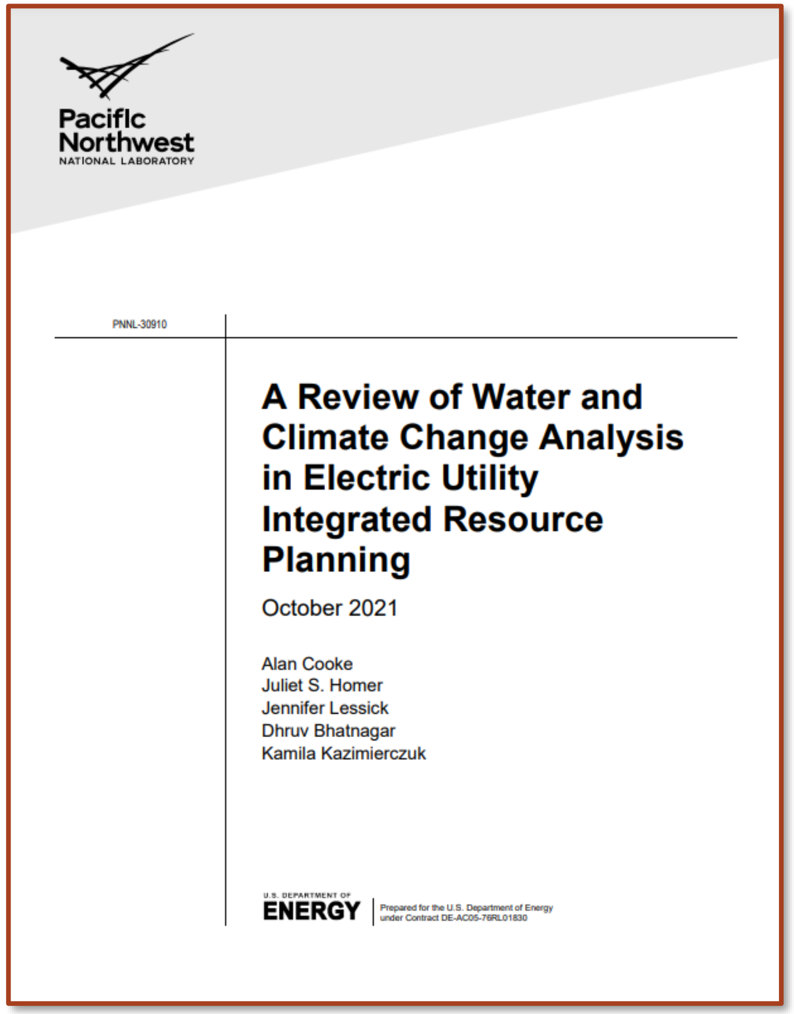
U.S. DEPARTMENT OF ENERGY | Prepared for the U.S. Department of Energy under Contract DE-AC05-76RL01830

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

Regional Diversity in IRPs

Reviewed 30 electric integrated resource plans to summarize best practices for analyzing and reporting on potential water-based and climate change risks within the integrated resource planning process - [White Paper]

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PNNL-30910

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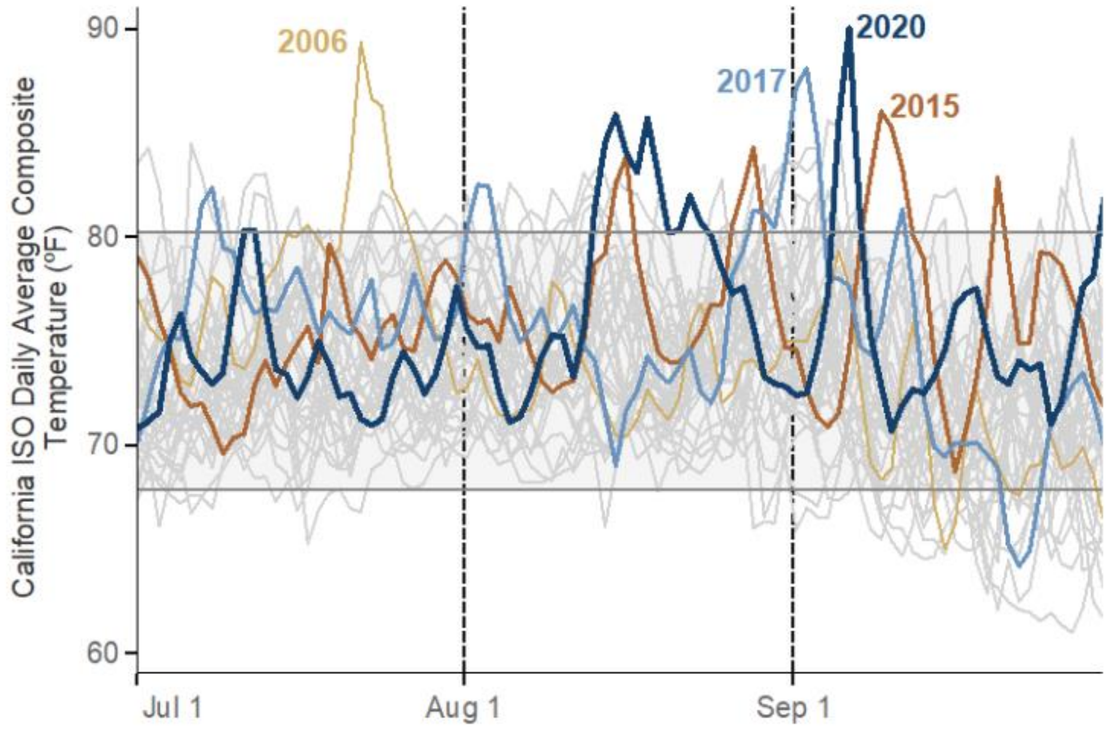
Impact of Climate Change and Water Availability on Resource Planning and Resource Adequacy

1. Water availability can impact amount and timing of power generation (thermal & hydro)
2. Changing temperatures can lead to changes in loads and demand side resources
3. Wholesale power markets and prices are impacted by changing generation and loads
4. Reliability is also impacted by extreme events, changing loads, and generation
5. Interregional climate change effects exist and can impact generating resource availability and market conditions

Taken together, these represent cumulative areas of significant potential uncertainty and impact

Resource Planning for System-wide Climate Resilience: Lessons Learned

Case study: CAISO outages, August 14 and 15, 2020



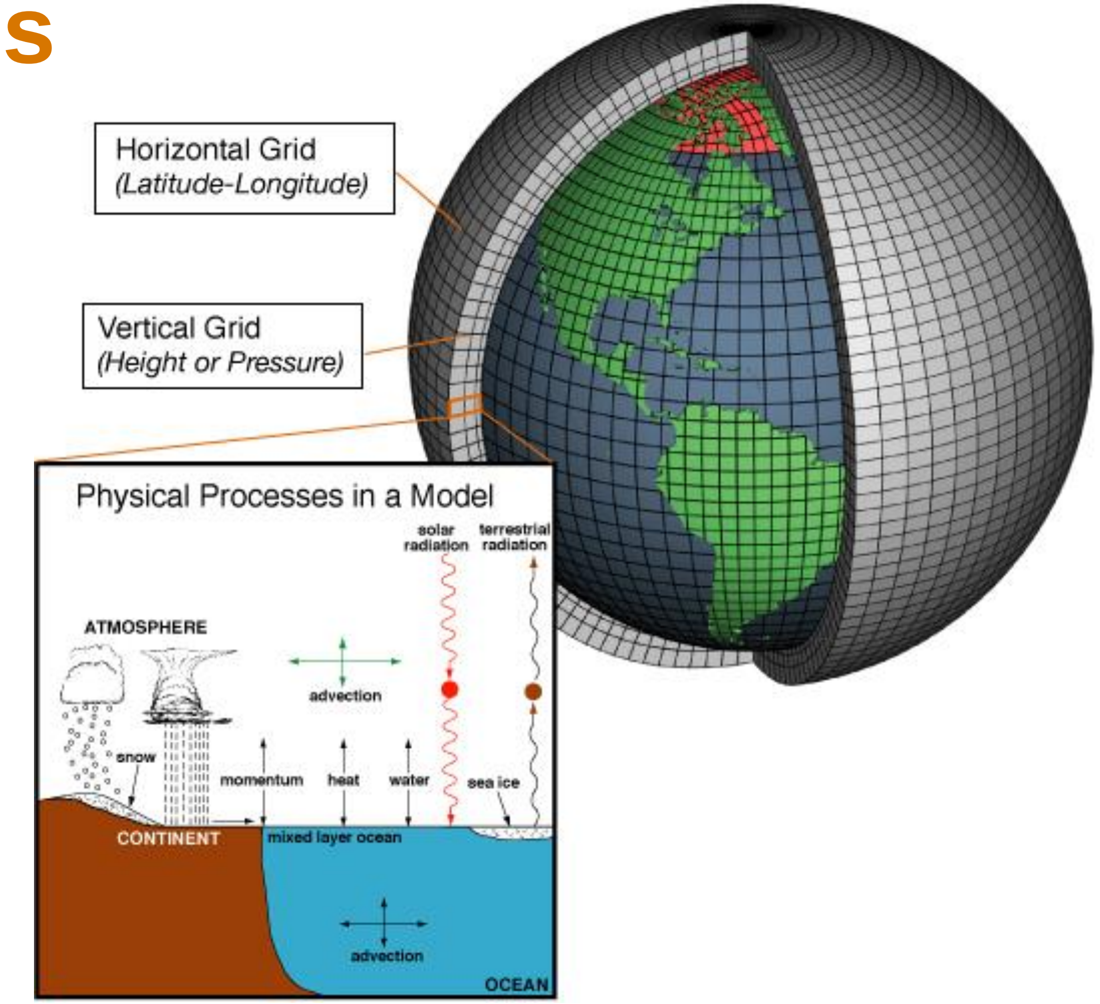
Source: CEC Weather Data/CEC Analysis

Demand was the result of a historic West-wide heat wave. http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf

- Extreme heat storm across the western US resulted in electricity demand exceeding electricity resource planning targets
- CA utilities forced to initiate temporary rolling service cuts due to shortage of electricity supplies
- Analysis of the incident by CAISO determined that **existing resource planning processes do not adequately account for climate change impacts**
  - Electricity demand forecasts used for resource adequacy requirements are based on average historic peak demand
  - Even with an added 15% planning reserve margin not sufficient for 2020 heatwaves

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**).

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Northwest Power and Conservation Council (NWPCC) Resource Planning Example

- NWPCC is a unique regional power planning organization established through an act of Congress
- They develop Northwest Power Plans every five years.
- In the latest power plan, they looked carefully at climate change:
  - Results from 10 General Circulation Model (GCM) studies were downscaled for the Pacific Northwest region
  - The River Management Joint Operating Committee (RMJOC), comprised of the Bonneville Power Administration, the Army Corps of Engineers and the Bureau of Reclamation in conjunction with the University of Washington and Oregon State University, performed the downscaling
  - Utilities and other stakeholders participated in public meetings held extensively throughout the downscaling process
  - 2 downscaling methods and 4 hydrological models were used to create 80 regional climate change scenarios
  - RMJOC chose 19 representative scenarios for detailed power system modeling
  - Council selected 3 of the 19 scenarios as representative of the entire ensemble

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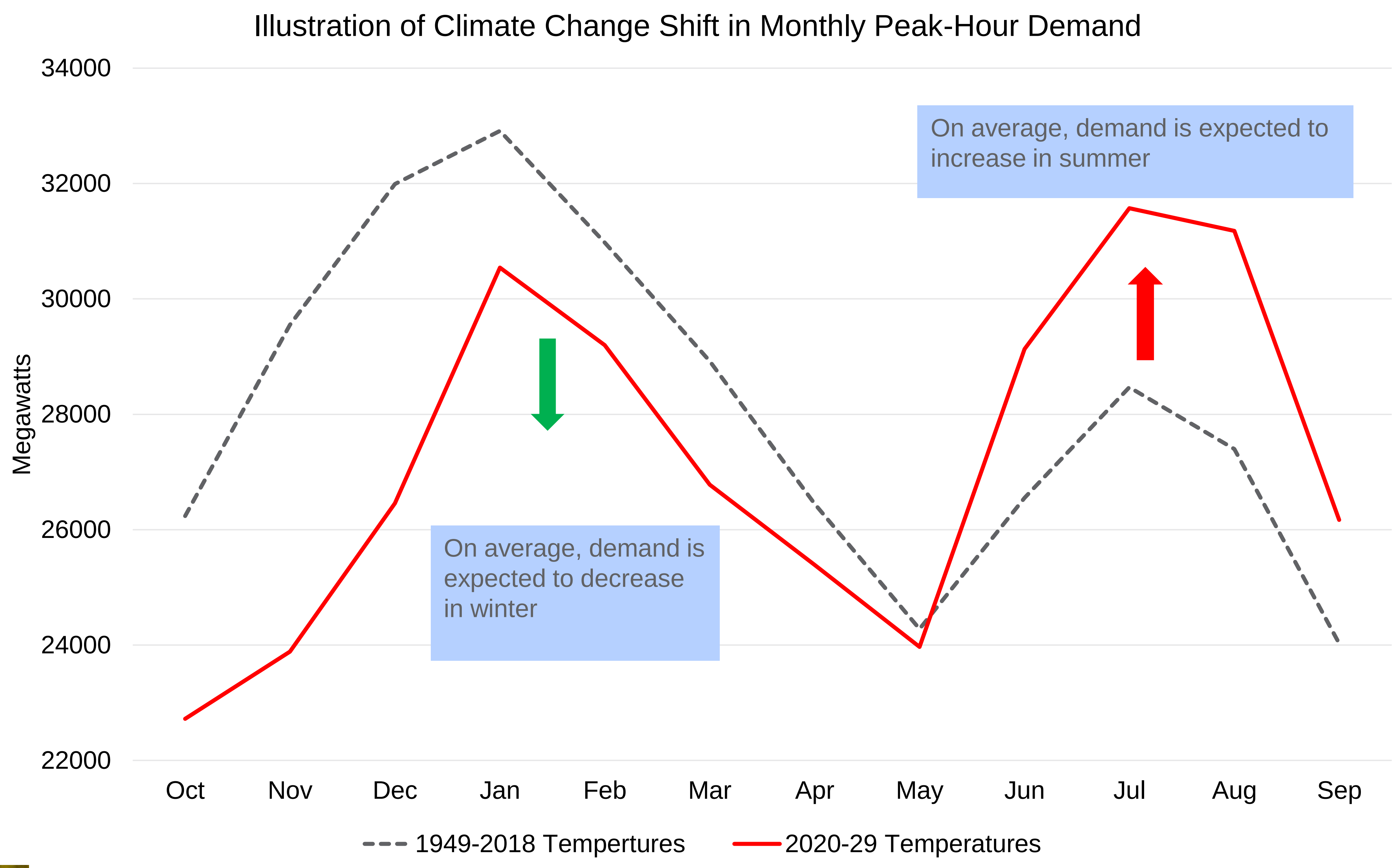
FOR A SECURE & AFFORDABLE ENERGY FUTURE

NWPCC Power Plan Example: Climate Change Shifts Seasonality of Electricity Demand



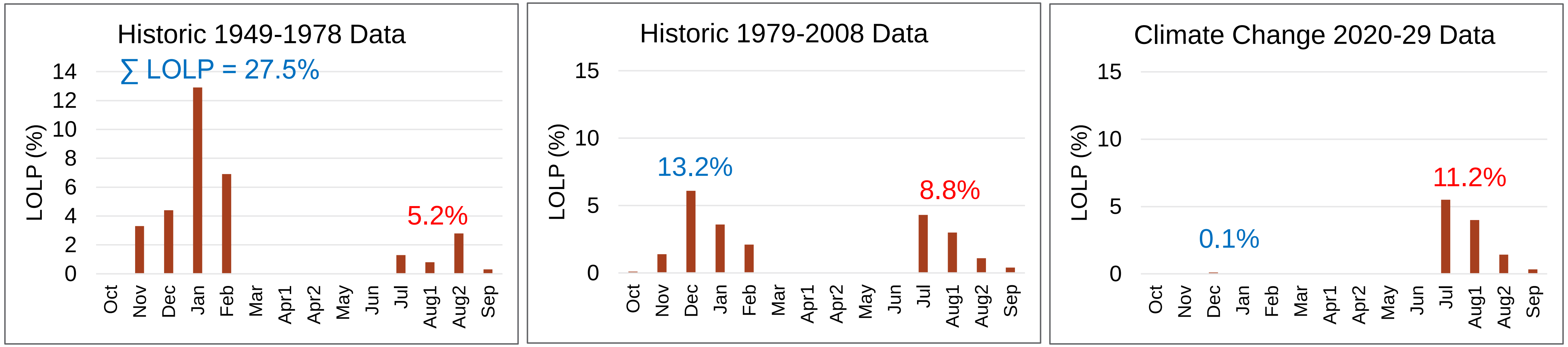
Dashed line represents monthly average peak-hour demand based on historic temperatures from 1949-2018.

Solid line represents monthly average peak-hour demand based on forecasted climate change temperatures for 2020-29.

Effect of Climate Change on Resource Adequacy

Seasonal Shift in Loss of Load Probability (LOLP) over Time

For illustration only – Not reflective of expected LOLP Values



For all studies, water year and temperature year (load) were in lockstep

- Left chart uses historical data from 1949-1978 (30 years)
- Middle chart uses historical data from 1979 to 2008 (30 years)
- Right chart uses climate change data for 2020-29 from three separate climate change scenarios (30 years total)

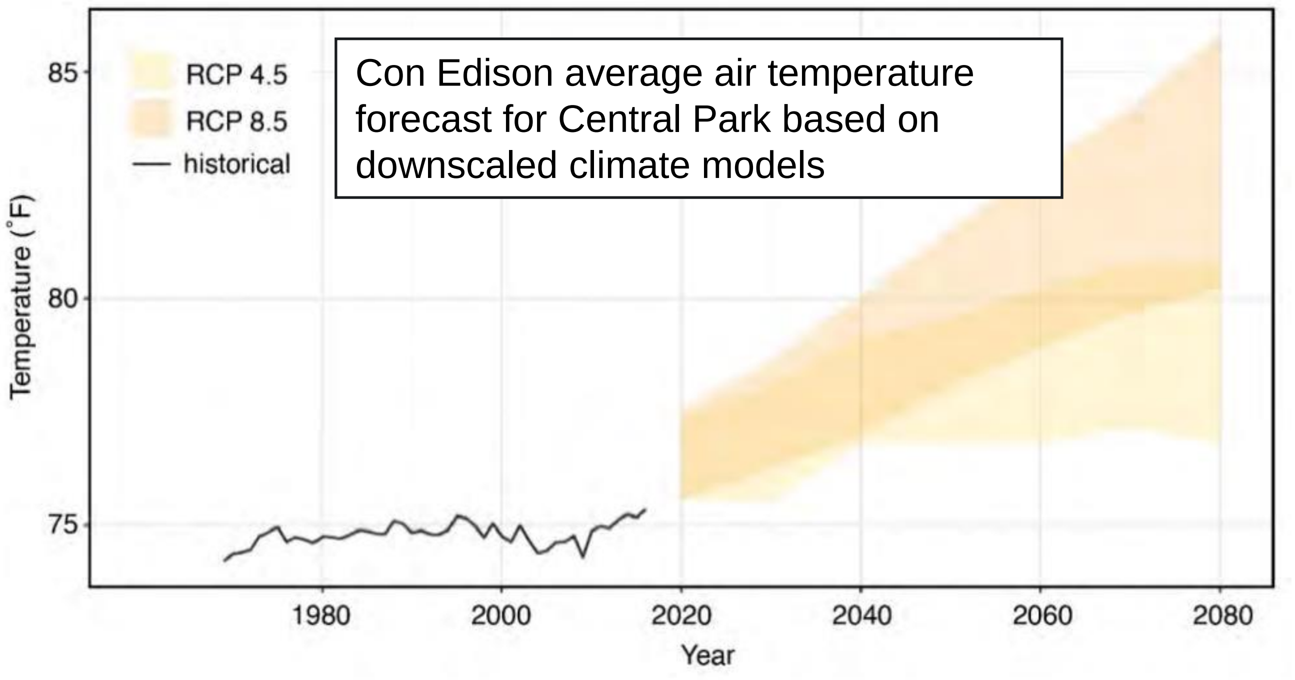
Over time, total winter LOLP declines and total summer LOLP increases

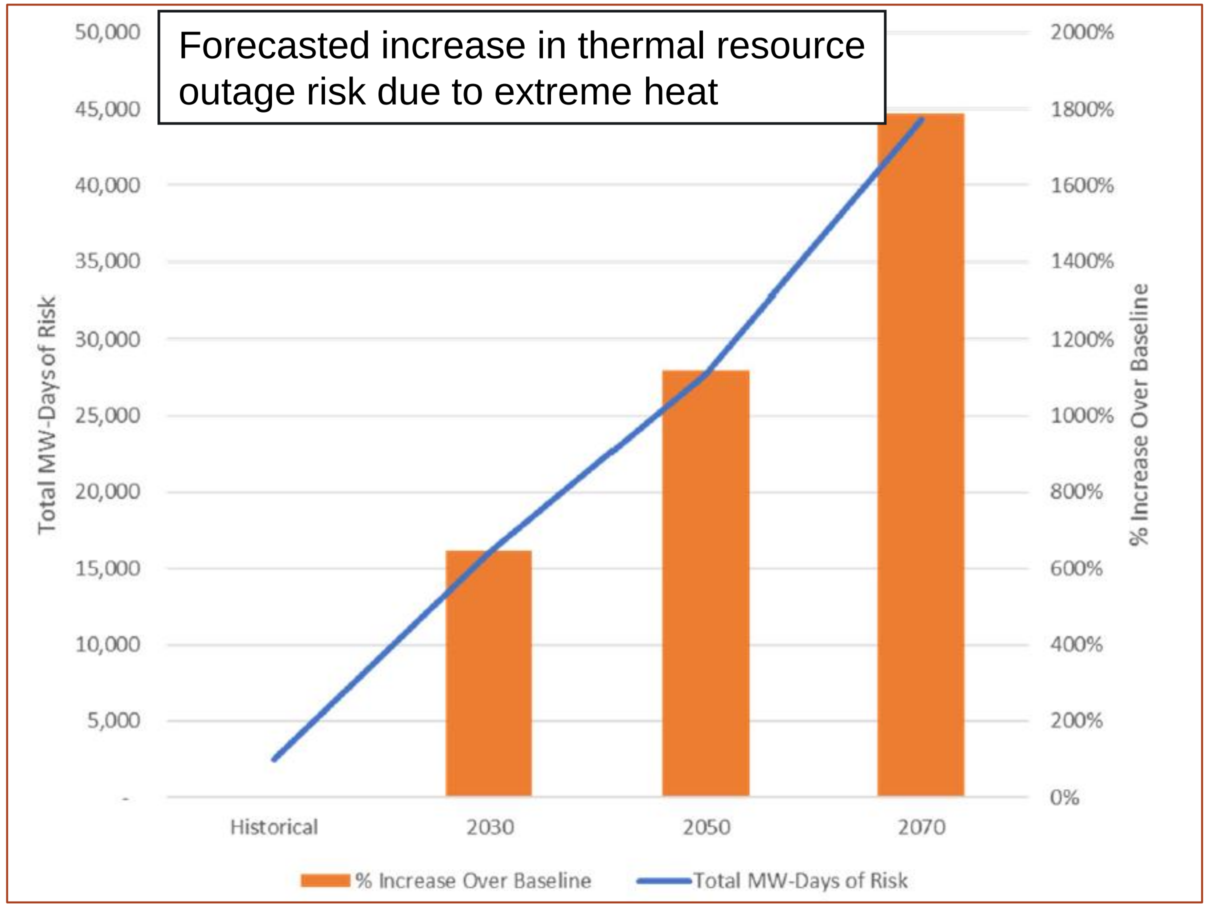
Forecasting with Climate Change

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.



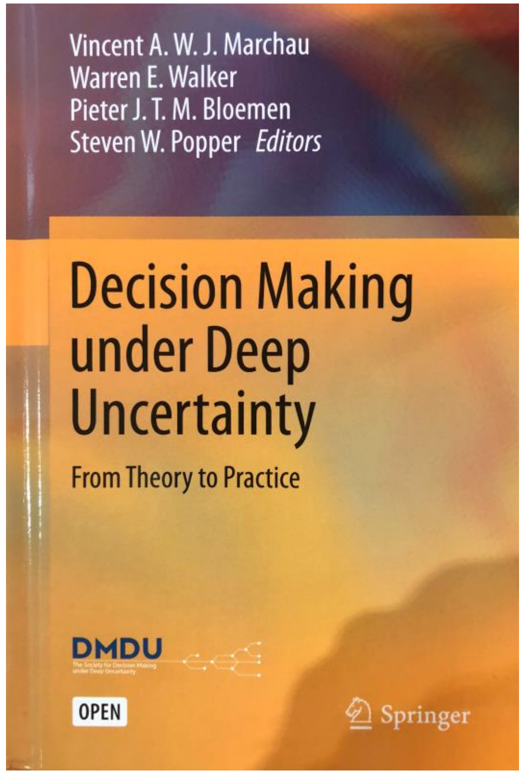


Southern California Edison . *Climate Change Vulnerability Assessment May 2022.*

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.



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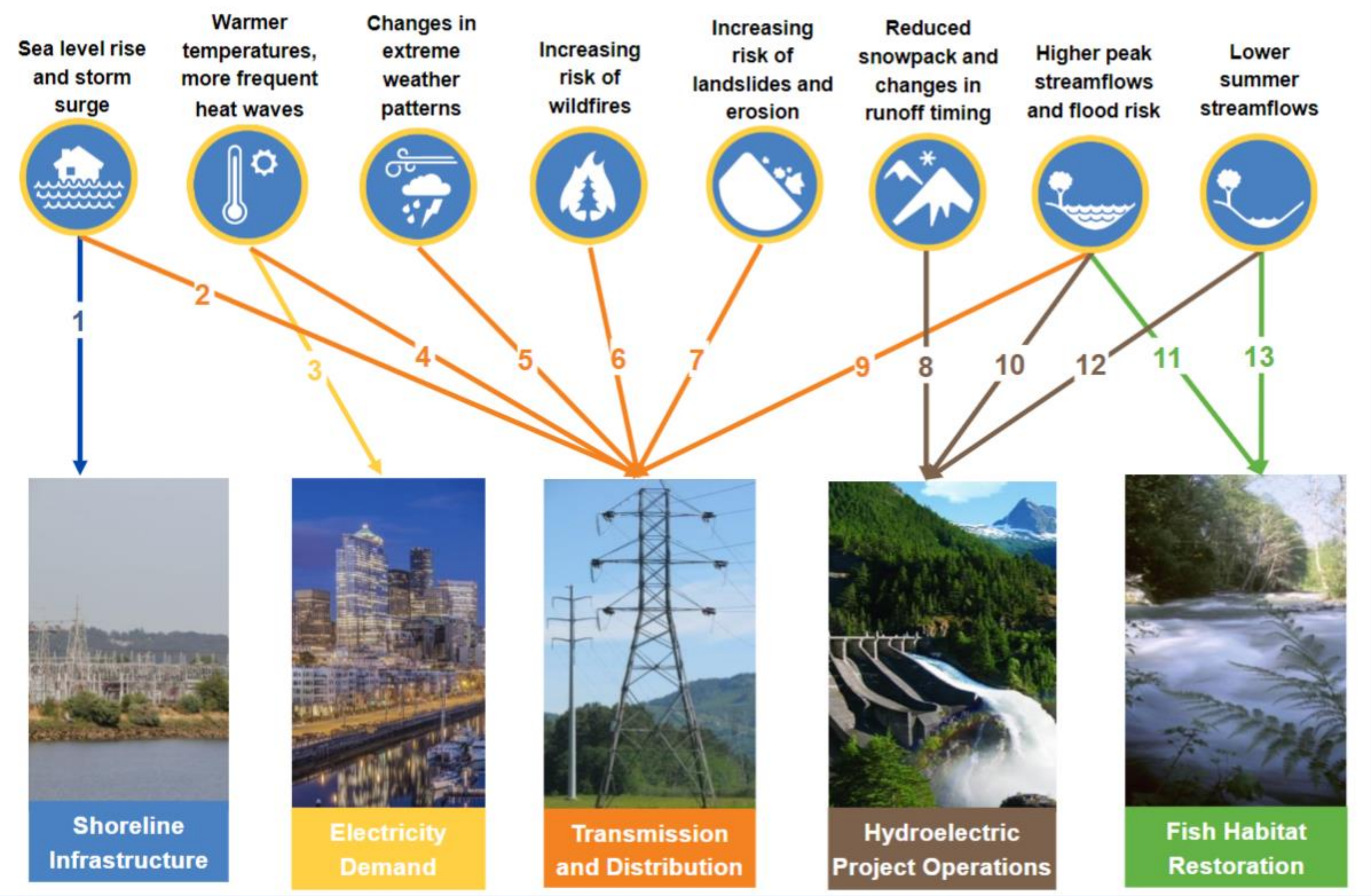
Seattle City Light Example



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	○	🟡	🔴	Low	–	–	Low	18-24
		2050	🟡			Mod	–	–	Low	
Transmission and distribution	Tidal flooding and salt water corrosion due to higher storm surge and sea level rise	2030	○	○	🟡	Low	–	Low	–	18-24
		2050	🟡			Low	–	Low	–	
	Reduced transmission capacity due to warmer temperatures	2030	🟡	○	○	Low	–	Low	–	34-39
		2050	🟡			Low	–	Low	–	
	More frequent outages and damage to transmission and distribution equipment due to changes in extreme weather	2030	○	🟡	🟡	Low	Low	Low	–	40-46
		2050	○			Low	Low	Low	–	
	More damage and interruptions of transmission and generation due to wildfire risk	2030	🟡	🔴	🟡	High	High	Med	–	47-53
		2050	🔴			High	High	Med	–	
	More damage to transmission lines and access roads due to landslide risk	2030	🟡	🟡	🟡	Med	Low	Med	–	54-58
		2050	🟡			Med	Low	Med	–	
	More damage and reduced access to transmission lines due to more frequent river flooding and erosion	2030	🟡	🟡	🔴	Med	–	Low	–	71-74
		2050	🔴			High	–	Low	–	
Energy Demand	Reduced electricity demand for heating in winter due to warmer temperatures	2030	🟡	🟡	🔴	Med	–	Low	–	25-33
		2050	🔴			High	–	Low	–	
	Increased electricity demand for cooling in summer due to warmer temperatures	2030	○	○	🔴	Low	–	Low	–	25-33
		2050	🟡			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.

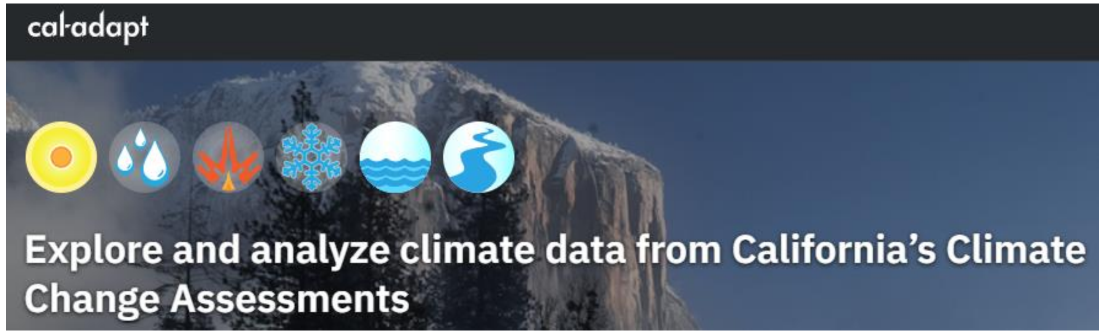
https://www.seattle.gov/light/enviro/docs/Seattle_City_Light_Climate_Change_Vulnerability_Assessment_and_Adaptation_Plan.pdf

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

Role for Regulators

- 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.

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.

Contacts and resources

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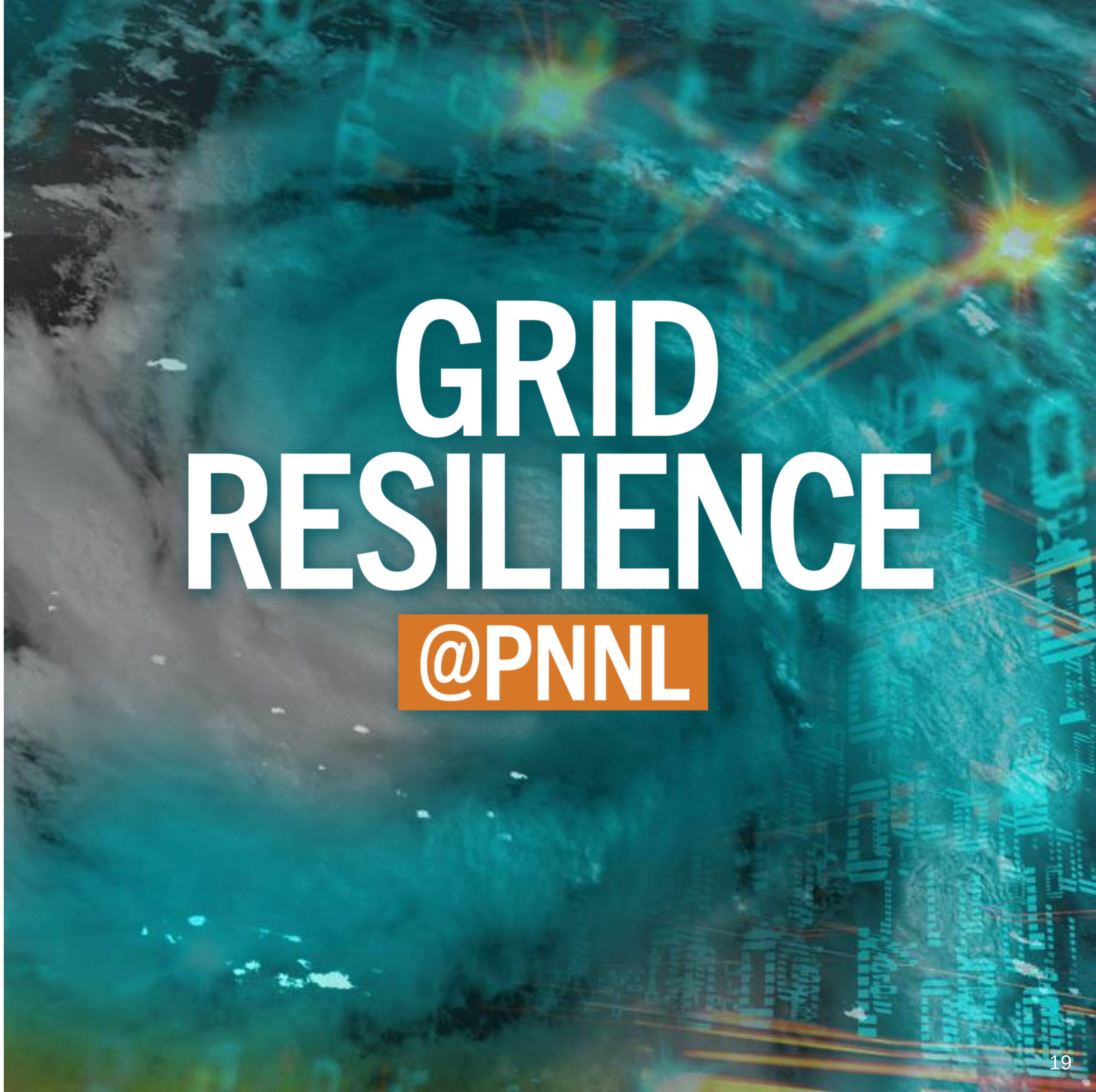
- Reports:
  - Emerging Best Practices in Planning for Climate Variability
  - A Review of Water and Climate Change Analysis in Integrated Resource Plans
  - Considerations for Resilience Guidelines in Clean Energy Plans
  - Grid Resilience to Extreme Events: Connecting Science to Investments and Policy

Thank you



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