Resource, asset, and contingency planning with climate variability

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Innovations in Electricity Modeling
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Agenda

- Introduction
- Resource planning
- Asset planning
- Contingency planning
- Weather data sources
- Downscaling climate models
- Stakeholder engagement
- Questions states can ask

Introduction

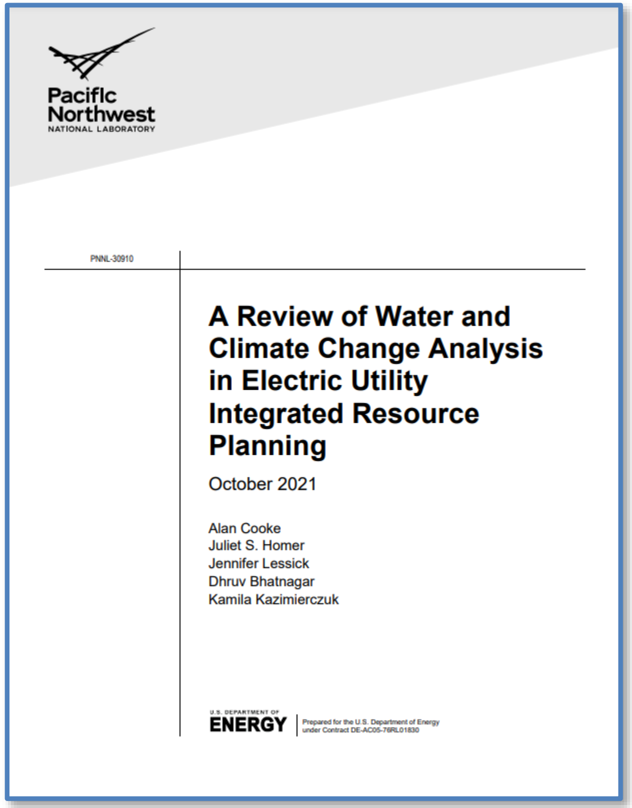
- Climate variability has implications for:
  - Resource planning
    - Resource adequacy and integrated resource planning
  - Asset planning
    - Supply infrastructure and physical delivery
  - Contingency planning
    - Climate-related vulnerabilities for assets, markets, and operations

Water and climate change analysis in electric utility integrated resource planning (1)

- 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
- Thermal generating facilities are having challenges with water availability:
  - Shortage of cooling water
  - Incoming cooling water too warm for optimal operation
  - Water discharge temperatures exceeding permit limits
  - Example: S&P Global Market Intelligence report identified 98.2 gigawatts (GW) of coal capacity at risk due to water stress in 2030
- Climate change effects on hydrological cycles may adjust the timing, temperature, and volume of water availability for thermal electric cooling and hydropower generation
- Climate change can also impact the timing and intensity of electric loads that utilities must serve, most notably for heating and cooling

Water and climate change analysis in electric utility integrated resource planning (2)

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

October 2021

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

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

Water and climate change analysis in electric utility integrated resource planning (3)

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U.S. Department of Energy

- Most IRPs presented no assessment of water availability issues
  - Only three of 30 IRPs studied water availability issues
    - Southwestern Public Service analyzed alternatives for a plant now facing ground water constraints
    - Tennessee Valley Authority analyzed cooling issues caused by water temperatures
    - Arizona Public Service presented considerable data on plans to ensure sufficient water for plants
- Northwest Power and Conservation Council, Tacoma Power, and Seattle City Light used downscaled climate data to identify impacts on loads and hydroelectric resources
- Puget Sound Energy, Vectren, and Entergy Mississippi IRPs analyzed historical data and identified trends for use in models
  - Vectren and Entergy Mississippi used cooling and heating degree day trends for load forecasting
  - Puget asked stakeholders whether they should use downscaled or trended historical data
  - Vermont Gas 2021 IRP included declining heating loads, increasing design temperatures
- <u>Best practices</u>:
  - Use downscaled global climate model weather data
  - Use historical data
    - ✓ With trends rather than a fixed average
    - ✓ Focused on recent history, not last 40 years or longer term

Resource planning for system-wide climate resilience: Lessons learned

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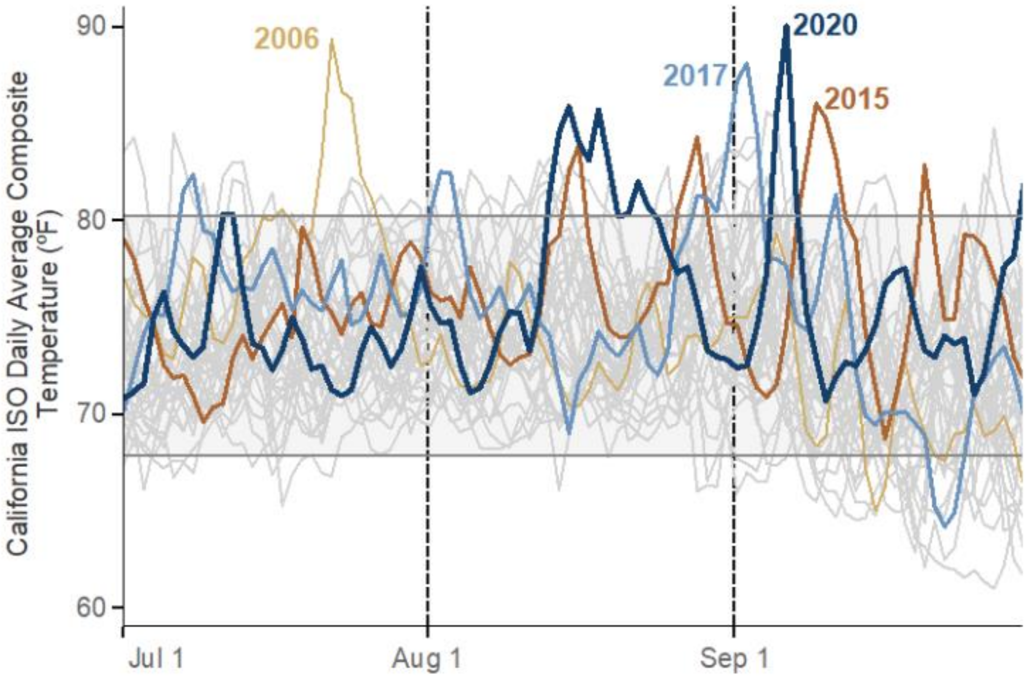
Case study: CAISO outages, August 14 and 15, 2020



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

Poll time

Climate vulnerability assessment

- A climate vulnerability assessment looks at where and how utility **assets** are at risk from the impacts of climate change, how those risks will manifest, and what the consequences will be to the system
- The assessment ultimately considers:
  1. the **exposure** of critical assets or operations to an adverse climate event
     - Critical assets are inventoried by category (to the right) and attributes
  2. the **probability of damage** to assets or disruption to operations as a result of exposure to those climate threats (risks posed by threat)
  3. the **likely consequences** if the event were to occur (severity of impacts).

Electric Power Sector Category	Electricity Asset Type
Generation	• Steam generator and turbine units • Generator cooling water intake systems • Water filtration and handling equipment • Electrical substation • Back-up power supply sources • Fuel handling and storage systems • Distributed generation units (like solar, back-up diesel units)
Transmission	• Long-distance transmission wires and towers • Station control buildings • Substation assets: – Circuit breakers – Grounding structure – Transformers and cooling systems – Bus bars – Underground cables – Protection/control equipment
Distribution	• Distribution transformers • Feeder circuits • Switches • Primary circuits • Electric poles
General	• Headquarters and operations centers • Fleet storage and service centers • Roads, parking lots, and right-of-way access routes

List of potentially vulnerable utility operations, from DOE 2016

Asset planning and operations (1)

- Many utility assets are predicated on specific temperature maximums (or minimums) and load ranges
- Temperatures above or below the specified max or min can lead to derating, damage and failure
- Existing equipment (transformers, conductors, etc.) may not be designed for temperatures being experienced
- Higher temperatures can reduce equipment capacity and increase maintenance requirements
- Higher temperatures also correspond to higher loads
- In some cases, utility assets now find themselves located in FEMA floodplains

- **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
- Utilities need to assess and potentially adjust their assumptions. Regulators can encourage them to do so and ask for updates on how they are doing this

Asset planning and operations (2)

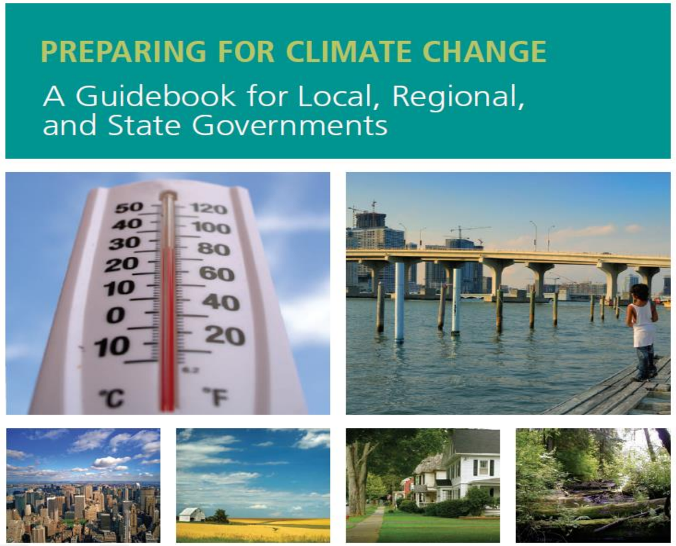
- **Maintenance cycles** may also need to be adjusted. Increased maintenance cycles may be needed to keep transformers going.
  - More emphasis on **vegetation management** is required in some areas.
  - Utilities may also change the amount and types of **spares kept on hand**.
- Some utilities now want more **observability** in the system to more actively monitor systems, including more sensors and more advanced distribution management systems.
- **Standards** may need to be reconsidered. Many design requirements come from standards. Standards vary based on region.
- Equipment **vendors** need to adapt equipment ratings and specifications.
- **Regulators** can be flexible with utilities as they move into operational regions they haven't seen before. There will inevitably be false starts. Some investments will not demonstrate value right away.
- Utilities can **learn from others** and don't have to start from scratch.
  - Can identify planning analogs and learn from other regions that have adapted their design requirements
  - Utility networking events can help (DistribuTECH, NRECA, APPA, Edison Institute). Regulators can support opportunities for networking.

Contingency planning

- **Contingency planning** refers to disaster or emergency response planning. It focuses on utilities' preparedness for one-off weather-related or other events (e.g., cyber-attacks), which could lead to service interruptions or safety issues.
- Asset and contingency planning often happens under the same umbrella – **climate resiliency planning**.
- Asset and contingency planning are typically part of a two-pronged process that involves the development of (1) climate vulnerability assessments and (2) climate resilience plans.
- Following are some tools for bringing climate change into utility planning:
  - Asset risk screening tools
  - Weather data sources
  - Guides/tools to aid in assessing climate related impacts and addressing the impacts

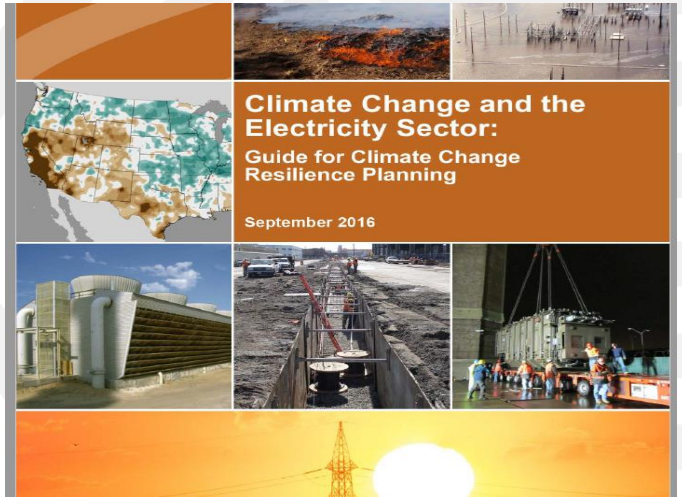
Risk screening tools

[NOAA US Climate Resilience Toolkit: Steps to Resilience]



[University of Washington Climate Impacts Group]

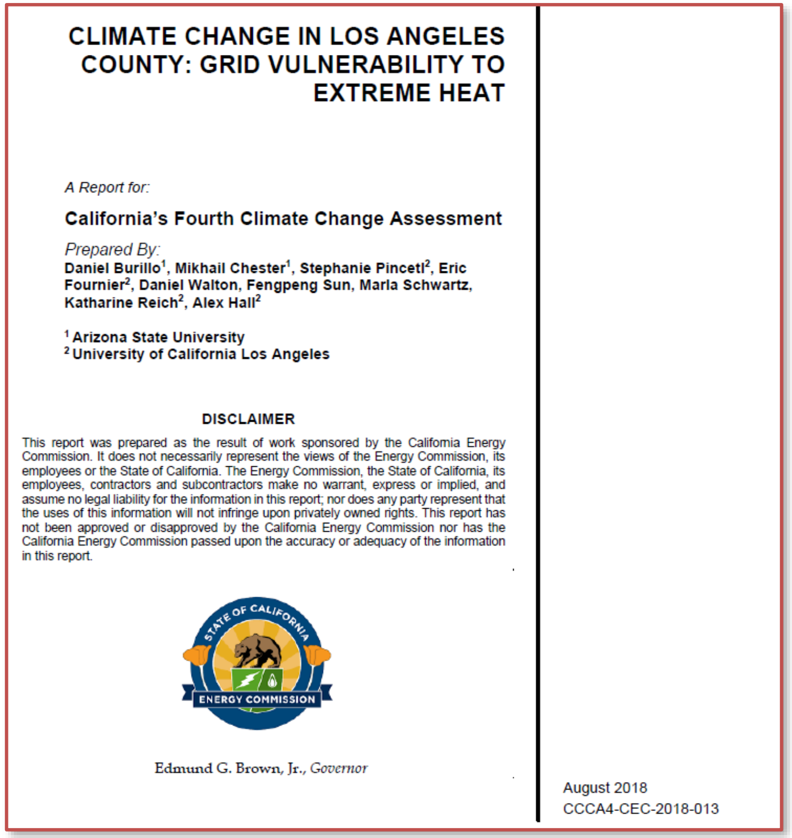
[US DOE Resilience Planning Guide]



- Additional resources
  - Georgetown Adaptation Clearinghouse
  - CPUC Climate Adaptation in the Electric Sector
  - NREL Power Sector Resilience Planning Guidebook

Screening example: 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:

Daniel Burillo[1], Mikhail Chester[1], Stephanie Pincetl[2], Eric Fournier[2], Daniel Walton, Fengpeng Sun, Marla Schwartz, Katharine Reich[2], Alex Hall[2]

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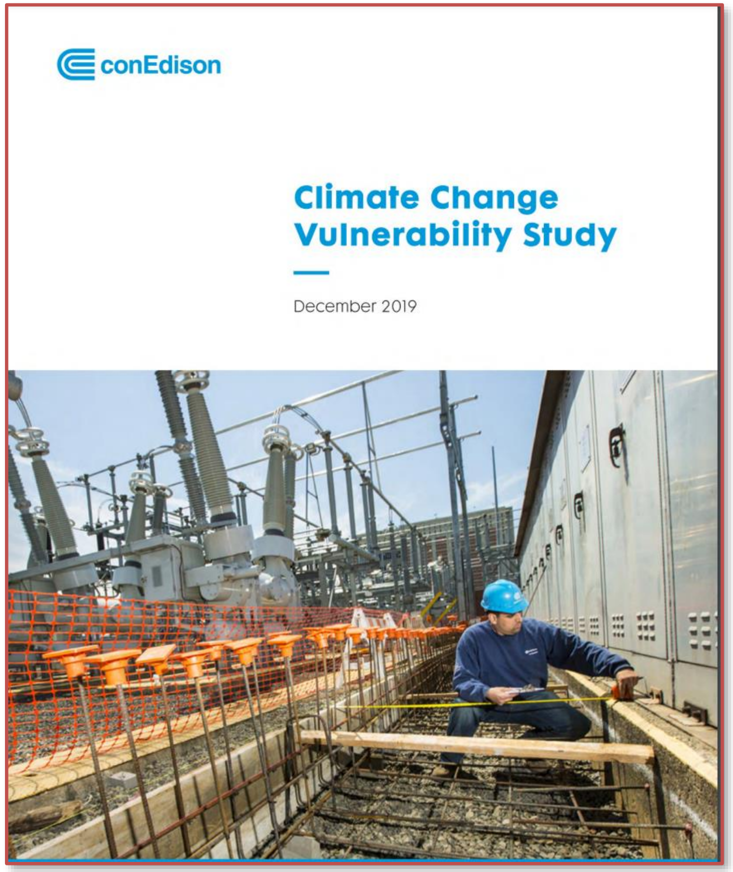
Edmund G. Brown, Jr., *Governor*

August 2018
CCCA4-CEC-2018-013

Screening example: ConEdison

- ConEdison 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
  - 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



Summary of Climate Change Resilience and Adaptation Activities of 2020

[Climate Change Vulnerability Study]

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.

conEdison

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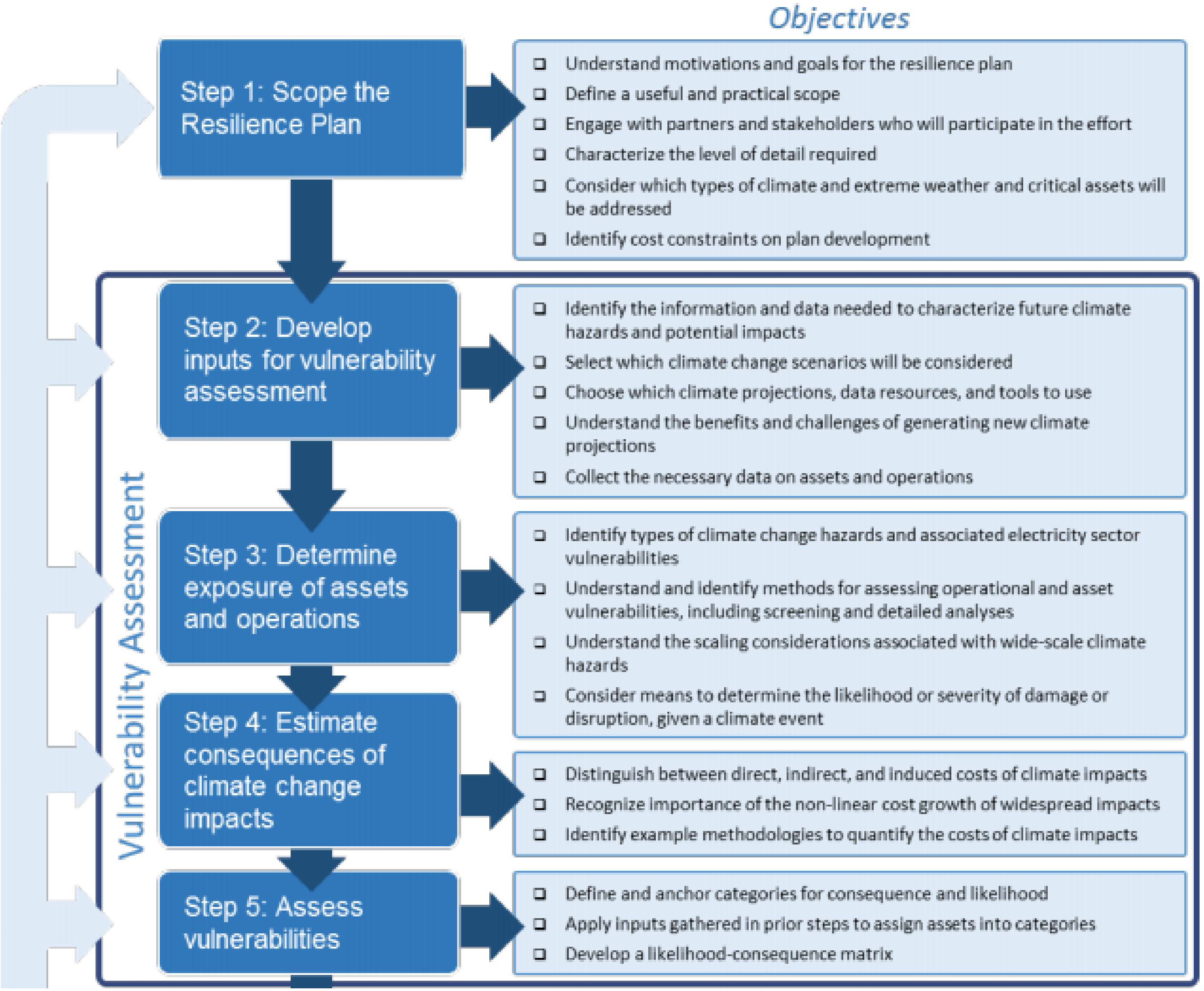
Steps in developing a climate change resilience plan - DOE, 2016* (1)



* This is illustrative. Steps in the DOE process are similar to, but different than, steps used in the CEC, ConEd and other examples

Steps in developing a climate change resilience plan - DOE, 2016 (2)

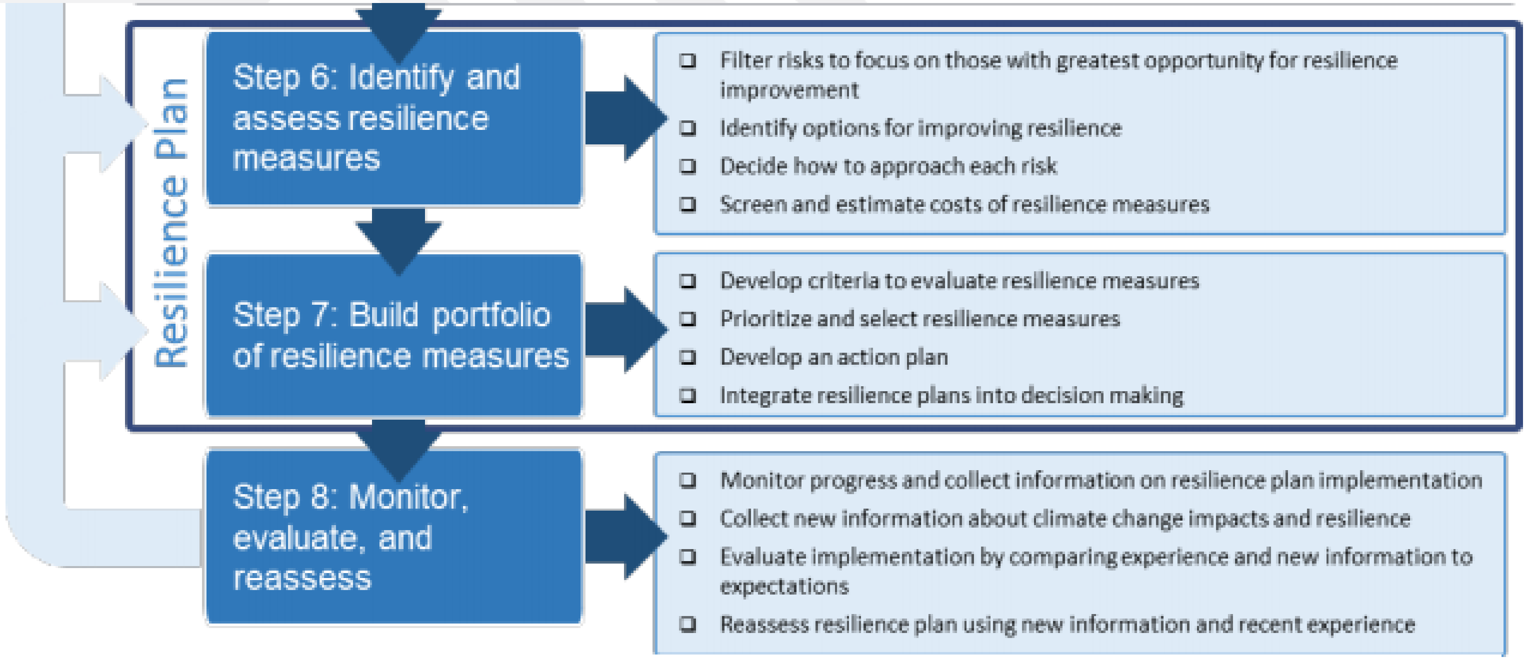


Figure 1. General resilience planning approach for conducting a vulnerability assessment and developing climate resilience solutions.

Weather data (1)

- IRPs typically use historical data in load forecasting and other processes requiring weather data.
- Future climate is not observable; only have models
- From what models tell us and from recent extreme weather events, not clear we can afford to plan to the weather of the past
- How do you make it documentable?
  - Use a credible, third party to downscale data
  - Cross-check data against other sources
  - Compare to analogs – Con Ed's 2019 climate resilience plan notes that with expected climate changes, New York City's temperature and precipitation in 2080 would resemble that of Little Rock, AR.

Weather data (2)

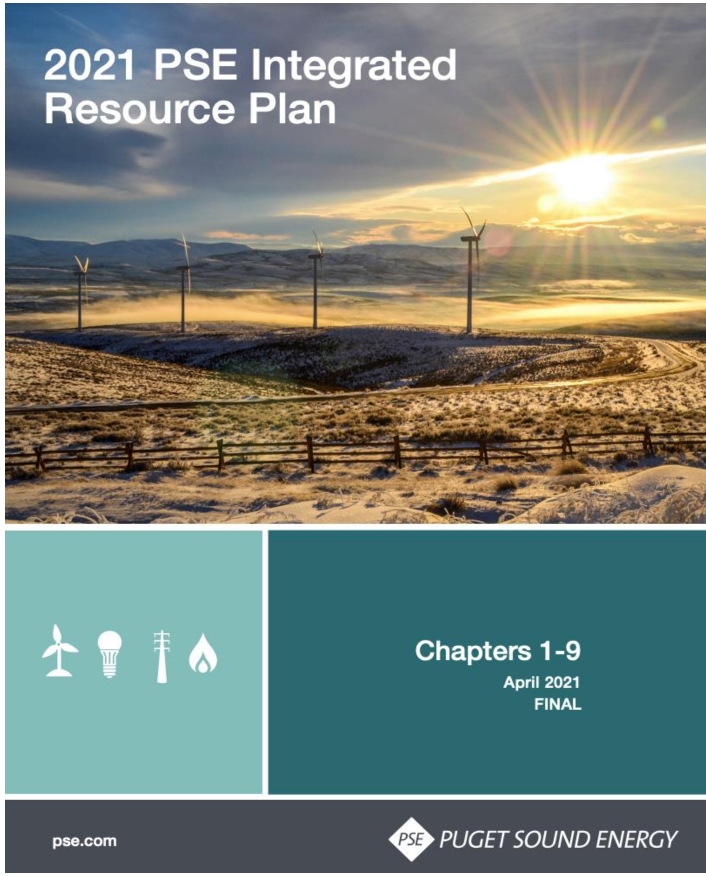
- Aggregated data summarizing potential future impacts available from on-line sources for screening, regulator oversight, and other analyses not needing hourly data
  - NOAA State Climate Summaries
  - The Climate Explorer, part of U.S. Climate Resilience Toolkit
- State-level / regional projects (examples)
  - North Carolina Climate Science Report
  - Cal-Adapt
- NOAA with regional universities and others
  - NOAA Regional Integrated Sciences and Assessments Program (NOAA RISA)
  - NOAA National Centers for Environmental Information, Regional Climate Centers
- Global climate models (NOAA) (IPCC)
  - NOAA dataset gallery

Downscaling climate models

- Downscaling climate models is labor intensive and expensive; potentially not feasible or cost effective to do in isolation
- Work with others to pool resources
- Regional pooling – Shared data / pooled resources offer cost-effective option
  - Bonneville Power Administration, Corps of Engineers, and Bureau of Reclamation downscaling study for joint operations of the PNW federal system – used by Northwest Power and Conservation Council, Tacoma Power, and Puget Sound Energy (maybe others)
  - New York City – Con Edison worked with Columbia University and ICF to perform their own downscaling and screening, expanding on methods used by New York City Panel on Climate Change
- Statewide forum for utilities / stakeholders to plan for climate adaptation — for example:
  - Cal-Adapt by California Energy Commission and partners contains statewide downscaled climate data and other research
  - California Energy Commission Climate Change Assessments (4th assessment)

Stakeholder engagement – Climate change projections

- Climate change impacts can also be addressed through stakeholder processes
  - Puget Sound Energy offers a good example of this in their 2021 IRP
  - Stakeholder discussions were used to reconcile uncertainties surrounding global modeling
- Puget Sound Energy's 2021 IRP presented stakeholders with three climate projection modeling options
  1. Redefine the "normal weather" period to include only the most recent 15 years
  2. Use historical trended temperatures
  3. Use the Northwest Power and Conservation Council downscaled climate model
- Stakeholders ultimately selected option 3



Other considerations

- How/what is the responsibility of **ratepayers** and how/what is the responsibility of **society/taxpayers**?
  - A blend of ratepayer and taxpayer investments in preparedness and investments in spare parts may be appropriate because a resilient grid has a lot to do with **societal value and community benefit**, not just ratepayer and utility benefit.
    - Benefit-cost analyses of resilience investments can include many hard to quantify benefits, such as the value of preventing lost gross regional product within a utility service territory.
    - It may make sense to share costs and benefits of investments that improve resilience
  - Examples of **cost sharing**
    - State of New Jersey paid to relocate electric equipment out of flood zone
    - District of Columbia is paying half the cost to underground lines

Questions states can ask

- Are utilities accounting for potential changes to water availability and temperature/loads in resource planning?
- Have utilities developed climate resilience plans?
- How are utilities assuring they are planning for the weather of the future and not just the weather of the past?
  - Are utilities using downscaled climate models to inform temperature, generation, and load projections?
  - Are utilities working with third parties on downscaling and cross checking against other sources?
  - Are utilities weighting more recent weather patterns in forecasts?
- Have utility asset operating assumptions been adjusted to account for changing weather conditions (temperature ranges and expected loads)?
- Are stakeholders being included in planning activities related to potential climate futures?
- How can knowledge sharing of “lessons learned” be facilitated to help utilities learn from one another in planning for climate change impacts?

Tools for identifying responses to climate risks

- DOE, Climate Change and the Electricity Sector: Guide for Assessing Vulnerabilities and Developing Resilience Solutions to Sea Level Rise, 2016
- ORNL, Extreme Weather and Climate Vulnerabilities of the Electric Grid: A Summary of Environmental Sensitivity Quantification Methods, 2019 – models to estimate climate impact on equipment life and capacity
- Grid hardening suggestions
  - DOE, Climate Change and the U.S. Energy Sector: Regional Vulnerabilities and Resilience Solutions, 2015
  - National Academies, Enhancing the Resilience of the Nation's Electricity System
- Example assessments
  - California Energy Commission - Climate Change in Los Angeles County: Grid Vulnerability to Extreme Heat, 2018
  - ConEdison Climate Change Vulnerability Study

Resources

DIRECT CLIMATE MODEL OUTPUTS

- Downscaled CMIP3 and CMIP5 Climate and Hydrology Projections (DCHP): https://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html
- MACA Downscaled CMIP5 Projections: https://toolkit.climate.gov/tool/maca-cmip5-statistically-downscaled-climate-projections

NATIONAL AND GLOBAL ASSESSMENT RESOURCES

- USGCRP Fourth National Climate Assessment (NCA): Summarizes climate change hazards for 10 regions across the United States as well as for 13 sectors or ecosystems. NCA5 is currently under development. https://nca2018.globalchange.gov/
- NOAA Regional Climate Trends and Scenarios for the U.S. National Climate Assessment: When used in conjunction the NCA report, this resource can provide locally detailed climate projections as well as useful deployment information. https://www.nesdis.noaa.gov/about/documents-reports/technical-reports
- IPCC Sixth Assessment Report (AR6): The premier assessment resource for global climate change projections. https://www.ipcc.ch/assessment-report/ar6/

Resources

INTERACTIVE TOOLS AND SOFTWARES

- U.S. Climate Resilience Toolkit: https://toolkit.climate.gov/tools?f%5B0%5D=field_workflow_step%3A57; across U.S.
- Cal-Adapt: https://cal-adapt.org/; provides a view of how climate change might affect California
- Cities Impacts & Adaptation Tool (CIAT): https://toolkit.climate.gov/tool/cities-impacts-adaptation-tool-ciat; supplies localized climate projections for cities across the Midwest
- DOE Sea-Level Rise (SLR) and Storm Surge Effects on Energy Assets: https://www.arcgis.com/home/item.html?id=e463abadcd9c4ef7982ae431e3fca7e7; mapping tool that allows users to view the major energy assets and coastal flooding risks along U.S. coastlines in 10 major metropolitan areas
- National Climate Change Viewer (NCCV): https://www.usgs.gov/ecosystems/climate-research-and-development-program/science/national-climate-change-viewer-nccv?qt-science_center_objects=0#qt-science_center_objects; allows users to view both graphical and tabular presentations of high-resolution, downscaled CMIP5 projections for four different scenarios
- NOAA Sea-Level Rise (SLR) Viewer: https://coast.noaa.gov/digitalcoast/tools/slr.html; allows users to identify potential inundation risks

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