National Landscape of Emerging Equity Metrics for Resilience

Presented by Josh Schellenberg, Affiliate, Berkeley Lab

California Public Utilities Commission
Climate Adaptation Equity Metrics Workshop

November 20, 2024

Agenda

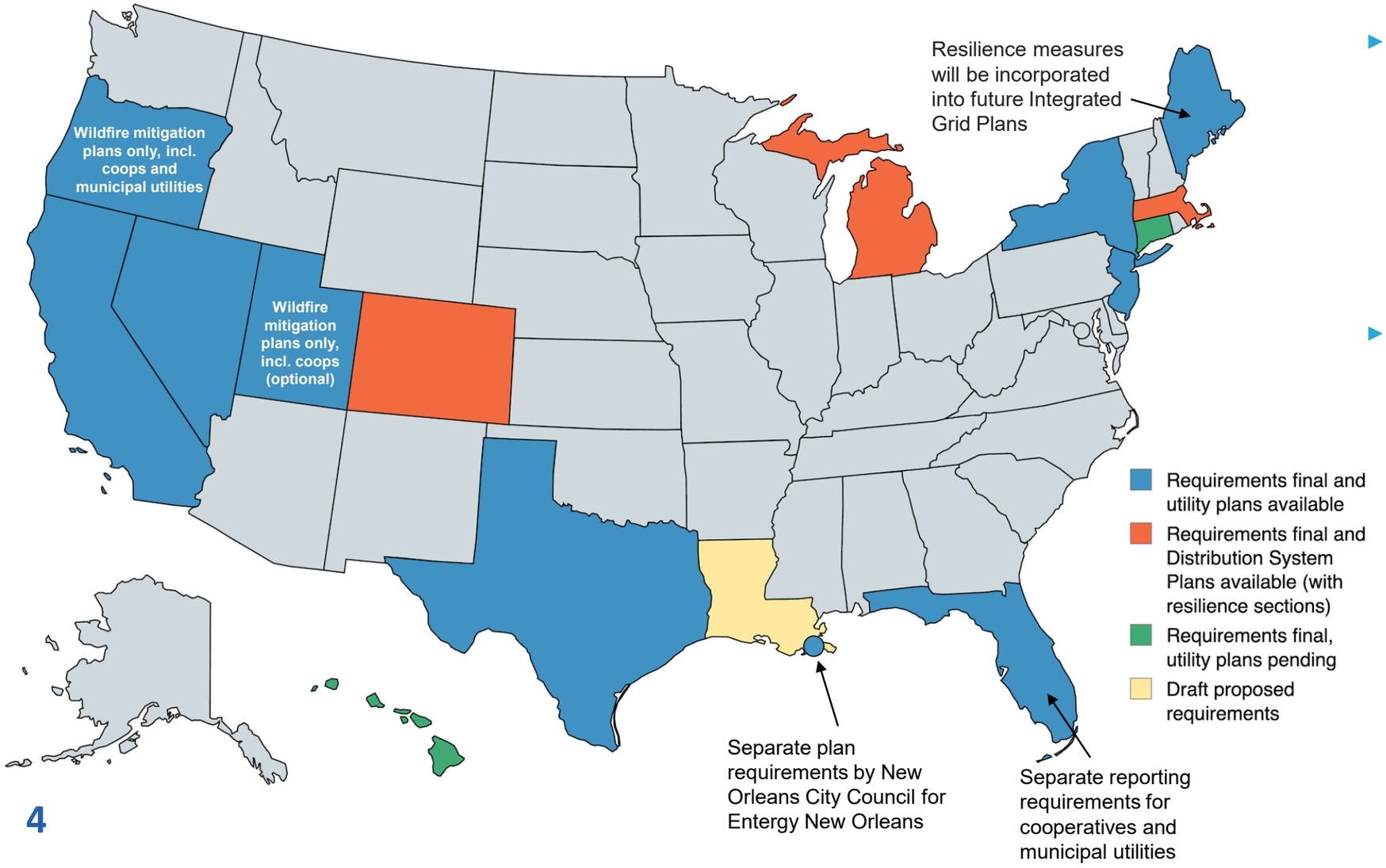
- National Landscape of Resilience Plans
- Resilience Performance Metrics
- Resilience Planning Analyses
- Considerations for Climate Change Vulnerability Assessments

GRID DEPLOYMENT OFFICE

GRID DEPLOYMENT OFFICE

National Landscape of Resilience Plans

Due to extreme weather, states are responding with resilience planning requirements for regulated utilities



- The four largest states – California, Texas, Florida and New York, accounting for a third of the U.S. population – have adopted resilience plan requirements, as well as nine other states.
- These requirements and associated utility plans point toward emerging best practices, including metrics for planning and performance reporting.

GDO GRID DEPLOYMENT OFFICE

At least 30 regulated utilities have filed resilience plans under state requirements from May 2022 to June 2024 (1)

State	Plan Name	Utility Plans (Recent Examples)
California	Wildfire Mitigation Plan	• PG&E (2024a) • Southern California Edison (2023) • SDG&E (2023)
California	Climate Change Vulnerability Assessment	• PG&E (2024b) • Southern California Edison (2022)
Colorado	Distribution System Plan	• Xcel Energy (2022) Phase I • Xcel Energy (2023) Phase II
Florida	Storm Protection Plan	• Florida Power & Light (2022) • Duke Energy (2022) • Tampa Electric (2022) • Florida Public Utilities (2022)
Maine	Climate Change Protection Plan	• Central Maine Power (2023) • Versant (2023)
Massachusetts (Section 92B)	Electric-sector Modernization Plan	• Eversource (2024) • National Grid (2024) • Unitil (2024)
Michigan	Distribution System Plan	• DTE Electric (2023) • Consumers Energy (2023) • Indiana Michigan Power (2023)

- These plans apply to over 47 million utility customers, with the aim to improve grid resilience for roughly 130 million people, or 39% of the U.S. population.

GRID DEPLOYMENT OFFICE

At least 30 regulated utilities have filed resilience plans under state requirements from May 2022 to June 2024 (2)

State	Plan Name	Utility Plans (Recent Examples)
Nevada	Natural Disaster Protection Plan	• NV Energy (2023a) Part 1 • NV Energy (2023b) Part 2
New York	Climate Change Vulnerability Study	• Con Edison (2023a) • Orange & Rockland (2023a) • RG&E and NYSEG (2023) • National Grid (2023a) • Central Hudson (2023a)
	Climate Change Resilience Plan	• Con Edison (2023b) • Orange & Rockland (2023b) • RG&E (2023) • NYSEG (2023) • National Grid (2023b) • Central Hudson (2023b)
Oregon	Wildfire Mitigation Plan	• Pacific Power (2023) • Portland General Electric (2023) • Idaho Power (2023)
Texas	T&D System Resiliency Plan	• Oncor (2024) • Centerpoint (2024)
Utah	Wildland Fire Protection Plan	• Rocky Mountain Power (2023)

GRID DEPLOYMENT OFFICE

Resilience Performance Metrics

Widely-used reliability metrics adapted for resilience could include a focus on populations of interest (1)

Reliability Metric	Description	Interpretation / Considerations
SAIFI	System Average Interruption Frequency Index	Total number of sustained interruptions that an average customer experiences over some time period
SAIDI	System Average Interruption Duration Index	Total number of minutes that an average customer is without power over some time period
CAIDI	Customer Average Interruption Duration Index	Time required to restore service for an average customer over some time period
MED	Major Event Day	Any day with a daily reliability metric that exceeds a statistically-defined threshold based on the previous five years of daily data (e.g., IEEE 1366 standard)

Source: Berkeley Lab

Widely-used reliability metrics adapted for resilience could include a focus on populations of interest (2)

Resilience Metric	Description
Major Storm-only SAIFI	SAIFI specifically for major storms (or MEDs in general)
Major Storm-only SAIDI	SAIDI specifically for major storms (or MEDs in general)
Customers Experiencing Long Interruption Durations (CELID)	Ratio of individual customers that experience interruptions with durations longer than or equal to a given time
Customer Minutes of Interruption (CMI)	Aggregate duration of all customer interruptions for major storms (or MEDs in general)
Time to Restore X% of Customers	Hours from outage onset time to restore a certain percentage of customers impacted (usually 50%, 90%, or 100%)
% of Customers Restored within 24 Hours of a major storm	Among customers impacted by a major storm (or MEDs in general), the percent that are restored within 24 hours of the outage onset time

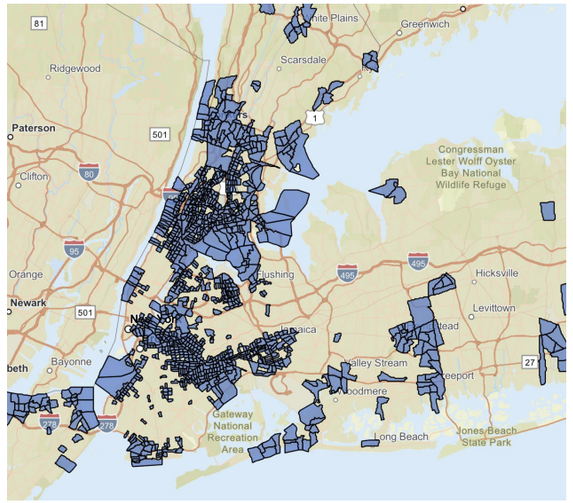
Source: Berkeley Lab

- To account for equity considerations, these resilience metrics can focus on populations of interest — e.g., life support customers and other vulnerable customers and communities
- Utilities can also report these resilience metrics for storm events and on an annual basis by storm category level

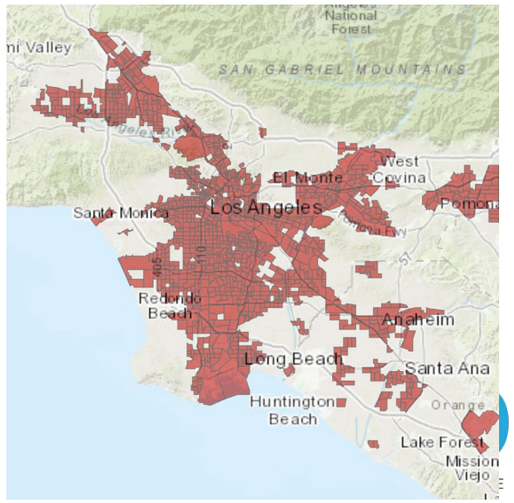
GRID DEPLOYMENT OFFICE

Accounting for critical facilities and specific groups of interest in resilience planning and metrics

- **Critical facilities:** Infrastructure which is essential for the health, safety, and economic well-being of a population (e.g., hospitals, fire stations, emergency operation centers, public drinking water facilities, sewer and wastewater facilities)
  - Examples of resilience plans that incorporate consideration of critical facilities: O&R (2023b), NYSEG (2023), RG&E (2023), National Grid (2023b)
- **Disadvantaged communities:** Census tracts designated by state governments for meeting a certain set of criteria
  - Examples of resilience plans that incorporate consideration of disadvantaged communities: SCE (2022), PG&E (2024b), DTE Electric (2023)
- Berkeley Lab report on resilience data, metrics, and analyses is forthcoming, including equity considerations



Source: NYSERDA



Source: OEHHA

Example from U.S. Department of Energy metrics guidance for Grid Resilience Formula Grants

Resilience goal – reduce restoration time for all new metered customers

Comparing duration of **all outages pre and post** new meters

Comparing duration of **MED outages pre and post** new meters

Also compare duration of **all outages between low and high adoption feeders**

BASELINE IMPACT METRICS (performance measures)									
					Baseline (*Before* Project Implementation) *Please ONLY enter values for the 5 years preceeding this Fiscal Year Report*				
Impact Metric (select from list)	Outage Type (select from list)	Does outage data include Major Event Days (MED)?	Coverage (select from list)	Coverage Type *(char lim: 100)*	2019 Value	2020 value	2021 Value	2022 Value	2023 Value
Customer Average Interruption Duration Index (CAIDI)	All Causes	Yes, all outages	Other (insert necessary info in "Coverage Type" field)	Feeders > 70% smart meter adoption	57	56	63	59	77
Customer Average Interruption Duration Index (CAIDI)	All Causes	Yes, MED Only	Other (insert necessary info in "Coverage Type" field)	Feeders > 70% smart meter adoption	51	71	57	79	100
Customer Average Interruption Duration Index (CAIDI)	All Causes	Yes, all outages	Other (insert necessary info in "Coverage Type" field)	Feeders < 40% smart meter adoption	67	56	93	53	83

MED: "Major Event Days"

Source: U.S. Department of Energy

GRID DEPLOYMENT OFFICE

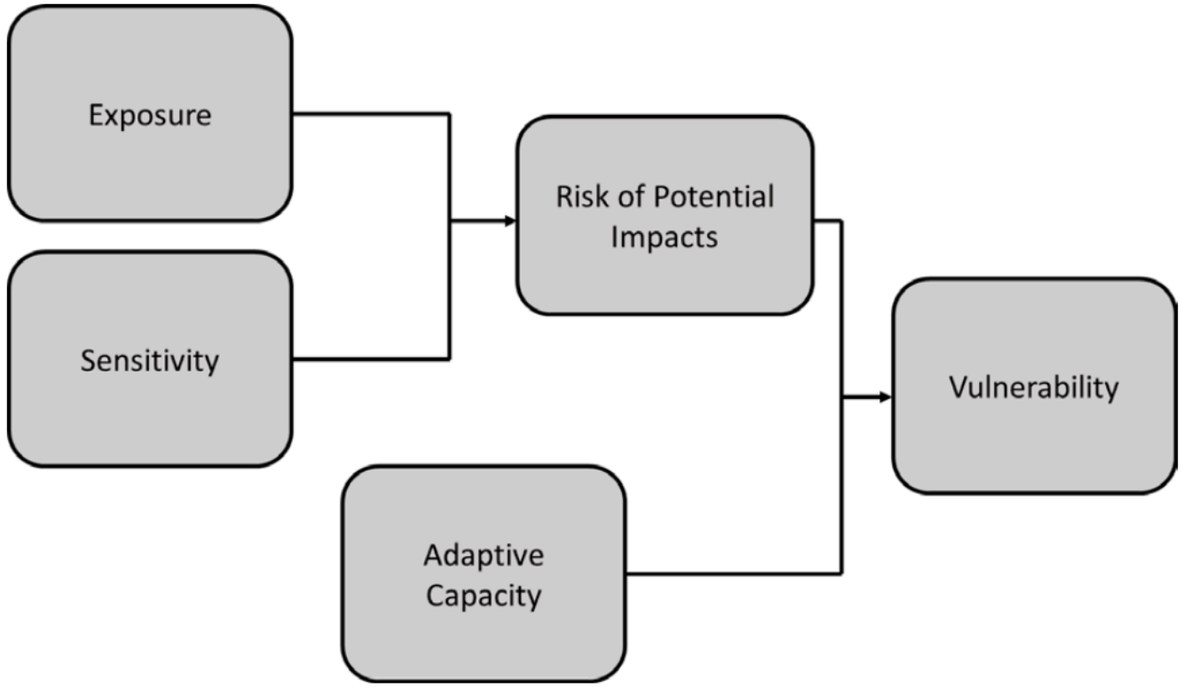
GRID DEPLOYMENT OFFICE

Resilience Planning Analyses

CPUC Decision 20-08-046 specifies vulnerability assessment methodology and defines adaptive capacity

- Two-step vulnerability assessment methodology based on California Department of Water Resources (DWR) Climate Change Vulnerability Assessment (2019)
    1. Combines exposure and sensitivity to determine risk
    2. Combines risk and adaptive capacity to determine vulnerability
- Adaptive Capacity – The broad range of responses and adjustments to daily and extreme climate change-related events available to communities. This includes the ability and resources communities have to moderate potential damages, take advantage of opportunities, and cope with consequences.

Figure 1-2 The Conceptual Framing of Vulnerability Utilized in This Assessment Has Been Widely Used in Other Climate Change Assessments.



Source: California DWR Climate Change Vulnerability Assessment (2019)

Climate change vulnerability rating components in recent utility plans

Exposure	Sensitivity	Consequence	Potential Impact	Examples
X	X	X		▪ Central Maine Power (2023) ▪ RG&E and NYSEG (2023) ▪ National Grid (2023a)
X	X			▪ Con Edison (2023a) ▪ O&R (2023a)
X	X	X	X	▪ Duke Energy Carolinas (2023)

Although resilience plans may not specifically refer to adaptive capacity, many utilities consider equity in climate change vulnerability ratings and/or resilience measure prioritization.

Prioritization analysis categories in resilience plans

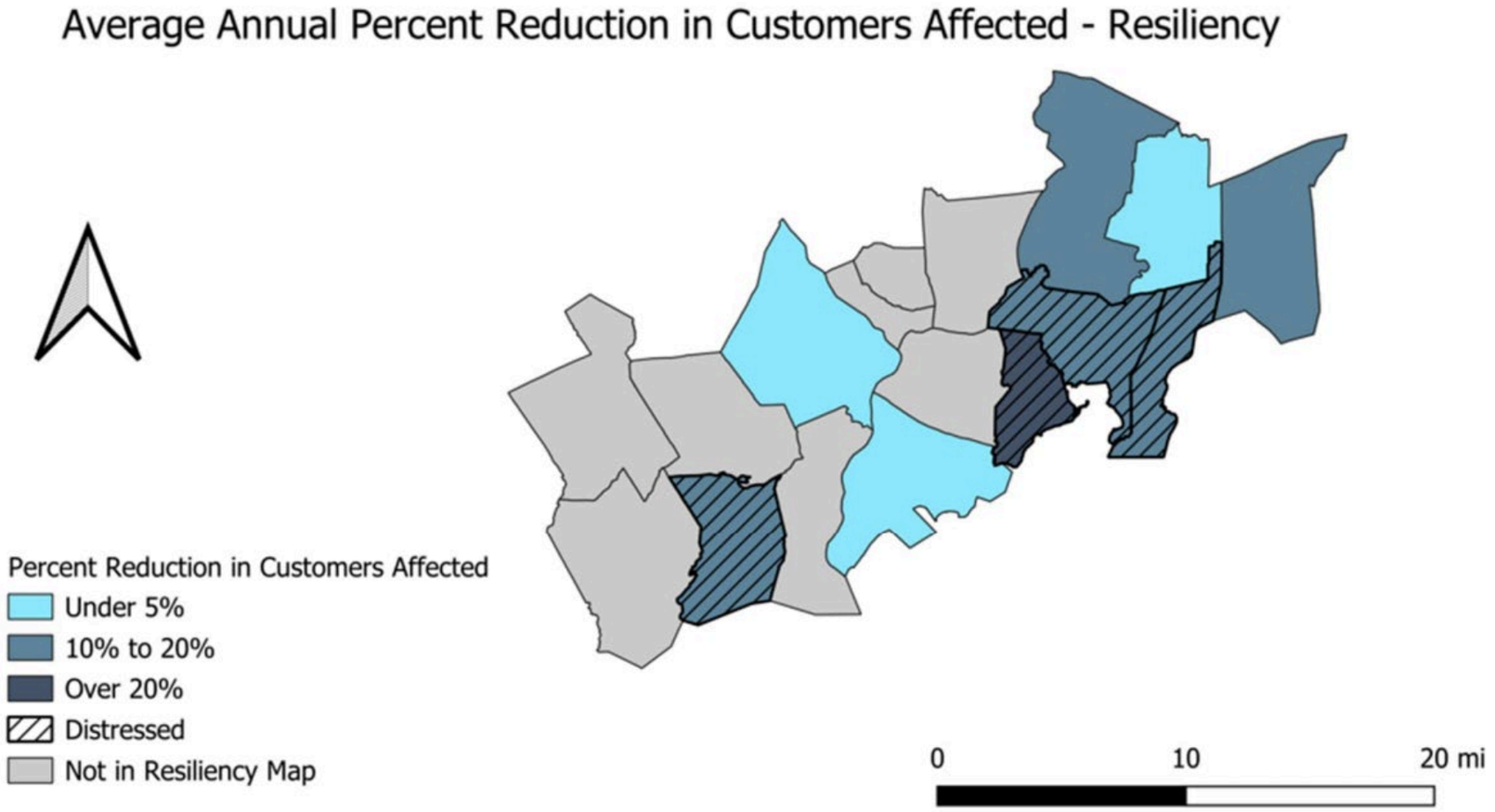
Analysis Category	Explanation	Key Planning Indicators	Methods & Tools	Utility Plan Examples
Benefit-Cost Analysis (BCA)	Compares and prioritizes resilience measures based on present value of monetized benefits and costs	Benefit-Cost Ratio (BCR)	Interruption Cost Estimate (ICE) Calculator, Power Outage Economics Tool (POET)	▪ Entergy New Orleans (2023) ▪ Tampa Electric (2022) ▪ United Illuminating (2024) ▪ Xcel Energy Minnesota (2019)
Risk-Based Analysis (RBA)	Estimation of cost-effectiveness based on risk reduction benefits (calculated by probability and associated consequences) and costs for a specific solution	Risk-Spend Efficiency (RSE), Value-Spend Efficiency (VSE)	Bowtie Method, Geospatial Analysis	▪ Duke Energy Florida (2022) ▪ Florida Public Utilities (2022) ▪ Idaho Power (2023) ▪ NV Energy (2023) ▪ Oncor (2024) – with BCA ▪ Pacific Power (2023) ▪ Portland General Electric (2023) ▪ Rocky Mountain Power (2023)
Multi-Criteria Assessment (MCA)	Comparison of benefits that are difficult to quantify or monetize, using composite indices, or that may not be effectively highlighted in financial analysis	Composite Indices	Index Calculation, Weighting	▪ Con Edison (2023b) ▪ Consumers Energy (2023) ▪ DTE Electric (2023) ▪ National Grid (2023b) ▪ NYSEG (2023) ▪ O&R (2023b) ▪ Portland General Electric (2022) ▪ RG&E (2023)

Utility plans may consider equity in vulnerability ratings and/or prioritization by:

1. Ensuring equitable distribution of resilience benefits
2. Including equity considerations in prioritization ranking
3. Understanding economic impacts for vulnerable populations, particularly for long duration power interruptions

GRID DEPLOYMENT OFFICE

United Illuminating (2024) – Equitable distribution of resilience benefits across communities



- United Illuminating serves 17 towns in Connecticut, seven of which are categorized as Distressed Municipalities – the state's most fiscally and economically stressed towns – by evaluating the tax base, personal income of residents, and residents' need for public services
- The utility's resilience plan prioritized circuits in nine towns, four of which are distressed municipalities and expected to receive similar benefits as other municipalities in terms of avoided power interruptions for customers

GRID DEPLOYMENT OFFICE

DTE Electric (2023) Global Prioritization Model scoring

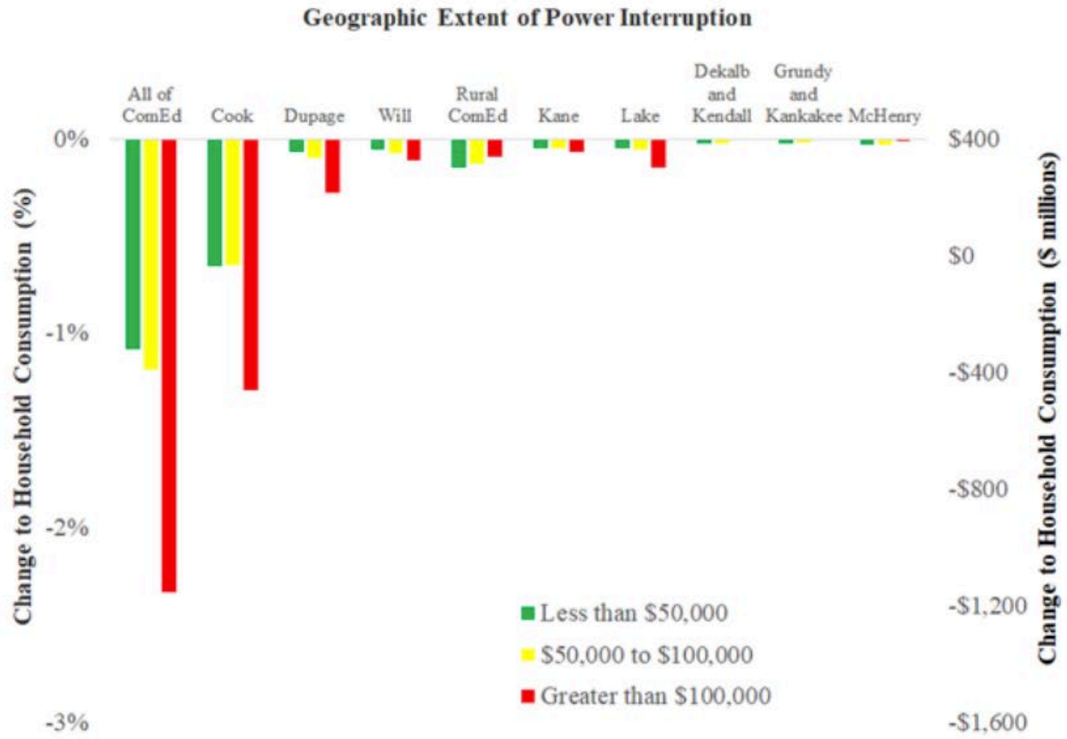
Impact Dimension	Drivers	Weight
Reduce Electrical Hazards	• Reduction in wire down events • Reduction in secondary network cable manhole events	3
Overload Relief	• Elimination of overloaded equipment	
SAIDI	• Reduction in duration of outage events	
SAIFI	• Reduction in frequency of outage events	
Regulatory Compliance	• MPSC staff's recommendation (March 30, 2010 report) on utilities' pole inspection program • Docket U-12270 – Service restoration under normal conditions within 8 hours • Docket U-12270 – Service restoration under catastrophic conditions within 60 hours • Docket U-12270 – Service restoration under all conditions within 36 hours • Docket U-12270 – Same circuit repetitive interruption of fewer than five within a 12-month period	2
Major Event Risk	• Reduction in extensive substation outage events that lead to a large amount of stranded load for more than 24 hours	
Capacity Relief	• Elimination of system capacity constraints	
Investment in EJ Communities	• Percent of customers impacted by investment in EJ communities	
O&M Avoidance	• Trouble event reduction and truck roll reduction • Preventive maintenance investment reduction	1
Capital Avoidance	• Trouble event reduction and truck roll reduction • Reduction in capital replacement either during equipment failures or avoided planned capital work	

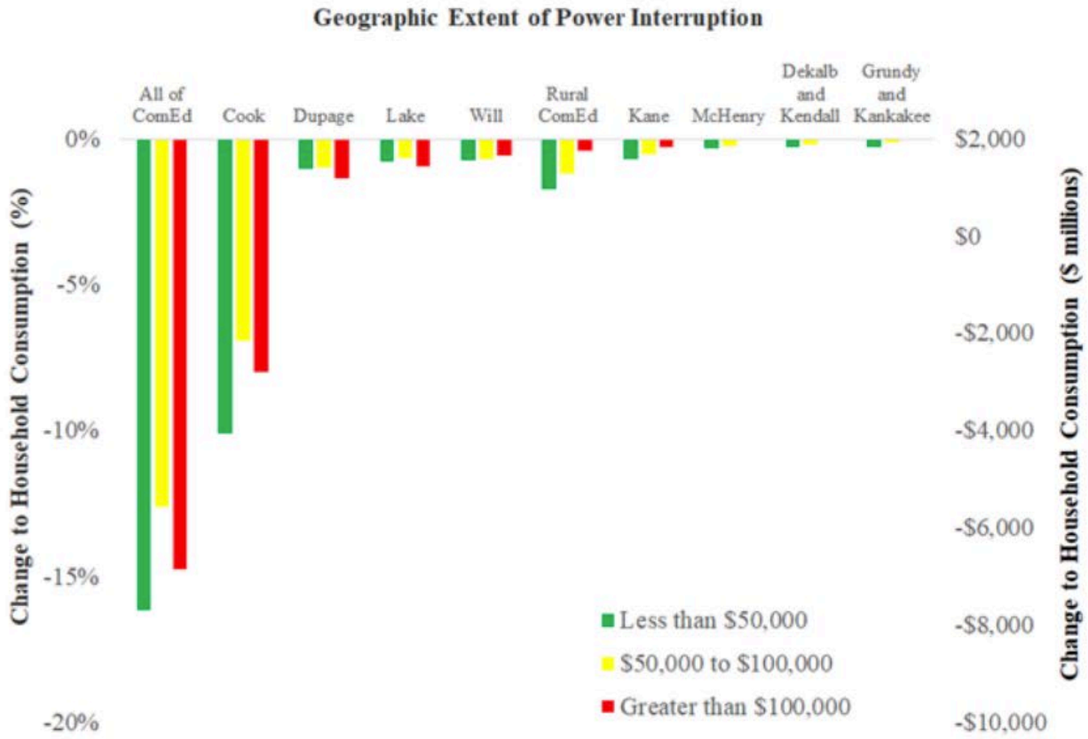
Scoring methodology recently updated to include investment in Environmental Justice (EJ) communities, reflecting input from stakeholders and Michigan Commission. This approach ensures that projects providing the most value in terms of safety, reliability, and load relief are prioritized, particularly for EJ communities.

GRID DEPLOYMENT OFFICE

POET study for ComEd: Low-income households have larger losses during longer interruptions (Larsen et al. 2024)

- **Left figure:** Highest-income households are expected to experience relatively higher losses to consumption during short duration interruptions
- **Right figure:** Lower-income households may experience more losses to consumption during a 14 day power interruption – highlighting equity concerns
- Different consumption losses for each interruption duration between income groups may be related to resilience strategies (e.g., higher-income households are more likely to temporarily relocate)





Considerations for climate change vulnerability assessments

- Equity-related performance metrics and planning analyses for resilience are emerging
- Although resilience plans may not specifically refer to adaptive capacity, many utilities consider equity in climate change vulnerability ratings and/or resilience measure prioritization
- Utility resilience plans may consider equity in vulnerability ratings and/or prioritization by:
  1. Ensuring equitable distribution of resilience benefits
  2. Including equity considerations in prioritization ranking
  3. Understanding economic impacts for vulnerable populations
- Planners may identify which customers are served by infrastructure vulnerable to climate change and further understand the benefits specifically for those customers, particularly avoided customer interruption costs that value reliability and resilience across groups

GDO GRID DEPLOYMENT OFFICE

Citations (1)

- Central Maine Power (2023). Climate Change Protection Plan. https://www.cmpco.com/documents/40117/126017242/Climate+Change+Protection+Plan.pdf
- Con Edison (2023a). Climate Change Vulnerability Study. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b40F8BC8A-0000-C237-B92D-FF39630B3E8D%7d
- Con Edison (2023b). Climate Change Resilience Plan. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7bC05CF38B-0000-CC16-ABC2-A376526F5B14%7d
- Consumers Energy (2022). Climate Change Risk, Vulnerability and Resiliency Report.
- Consumers Energy (2023). Electric Distribution Infrastructure Investment Plan (2024-2028). https://mi-psc.my.site.com/sfc/servlet.shepherd/version/download/0688y00000A3A9WAAV
- DTE Electric (2023). 2023 Distribution Grid Plan. https://mi-psc.my.site.com/sfc/servlet.shepherd/version/download/0688y00000A4YUXAA3
- Duke Energy Florida (2022). Storm Protection Plan. https://www.floridapsc.com/library/filings/2022/11327-2022/11327-2022.pdf
- Duke Energy Carolinas (2023). DEC/DEP T&D Climate Resilience and Adaptation Report. https://www.duke-energy.com/-/media/pdfs/our-company/carolinsresiliencetransdiststudyfinal.pdf
- Entergy New Orleans (2023). System Resiliency and Storm Hardening Plan. https://cdn.entergy.com/userfiles/content/future/ENO-resilience-filing-4-17-2023.pdf
- Florida Public Utilities (2022). Storm Protection Plan 2022–2031. https://www.floridapsc.com/library/filings/2022/11316-2022/11316-2022.pdf
- Idaho Power (2023). 2024 Wildfire Mitigation Plan. https://docs.idahopower.com/pdfs/Safety/WildfireMitigationPlan.pdf
- Larsen et al. (2024). Power Outage Economics Tool: A Prototype for the Commonwealth Edison Service Territory. https://emp.lbl.gov/publications/power-outage-economics-tool-prototype
- National Grid (2023a). Climate Change Vulnerability Study. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7bD001CD8A-0000-CC39-BDF3-FE8300353FF9%7d
- National Grid (2023b). Climate Change Resilience Plan. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b107AF38B-0000-C79C-90B4-B7A8DDC4B15E%7d
- NV Energy (2023). 2024 Triennial Natural Disaster Protection Plan Part 1 and 2. https://pucweb1.state.nv.us/PDF/AxImages/DOCKETS_2020_THRU_PRESENT/2023-3/24369.pdf and https://pucweb1.state.nv.us/PDF/AxImages/DOCKETS_2020_THRU_PRESENT/2023-3/24370.pdf
- NYSEG (2023). Climate Change Resilience Plan. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7bD030F38B-0000-C116-9CC6-FE546E842502%7d

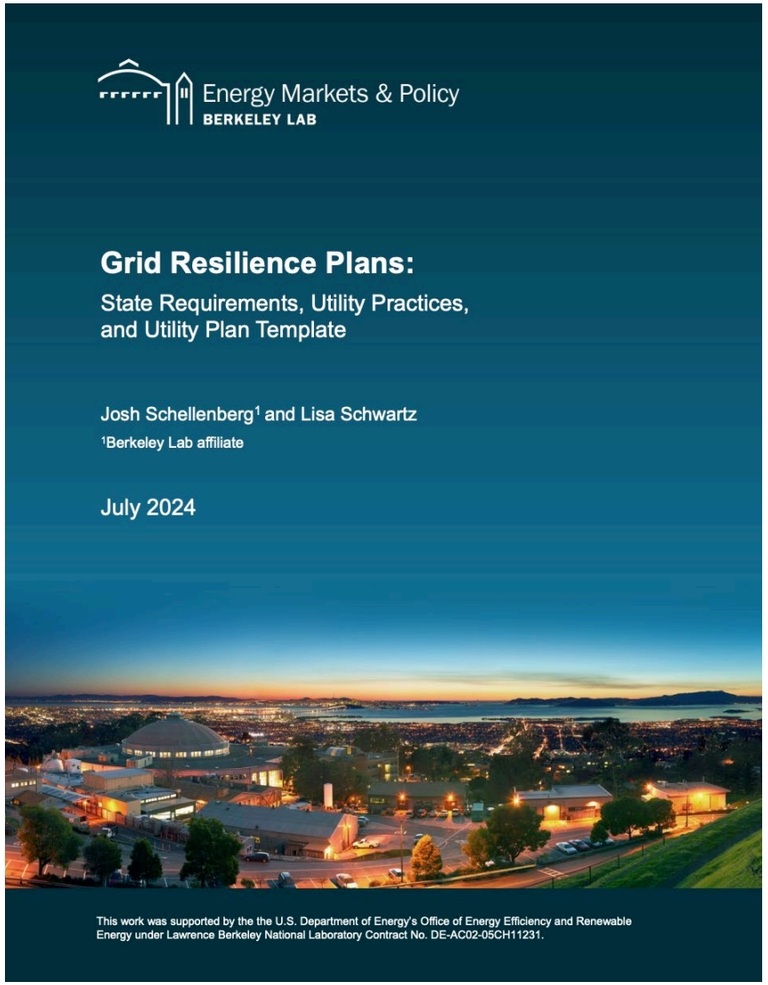
GRID DEPLOYMENT OFFICE

Citations (2)

- NYSEG (2023). Climate Change Resilience Plan. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7bD030F38B-0000-C116-9CC6-FE546E842502%7d
- Oncor (2024). System Resiliency Plan. https://interchange.puc.texas.gov/search/documents/?controlNumber=56545&itemNumber=3
- Orange & Rockland (2023a). Climate Change Vulnerability Study. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b8046BD8A-0000-C81D-9CA2-5E1857AF2CFD%7d
- Orange & Rockland (2023b). Climate Change Resilience Plan. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b00C7F38B-0000-C913-BC7A-2E9ADAC51421%7d
- Pacific Power (2023). Oregon Wildfire Mitigation Plan. https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/wildfire-mitigation/PacifiCorp_2024_WMP_12-29-23.pdf
- Portland General Electric (2022). Distribution System Plan. https://downloads.ctfassets.net/416ywc1laqmd/2Fr2nVc4FKONetiVZ8aLWM/b209013acfedf1125ceb7ba2940bac71/DSP_Part_2_-_Full_report.pdf
- Portland General Electric (2023). 2024 Wildfire Mitigation Plan. https://edocs.puc.state.or.us/efdocs/HAQ/um2208haq325939023.pdf
- Portland General Electric (2022). 2023 Wildfire Mitigation Plan. https://edocs.puc.state.or.us/efdocs/HAQ/um2208haq12626.pdf
- PG&E (2024a). 2023-2025 Wildfire Mitigation Plan R4. https://www.pge.com/assets/pge/docs/outages-and-safety/outage-preparedness-and-support/pge-wmp-r4-010824.pdf
- PG&E (2024b). Climate Adaptation and Vulnerability Assessment. https://www.pge.com/tariffs/assets/pdf/adviceletter/GAS_4914-G.pdf
- RG&E and NYSEG (2023). Climate Change Vulnerability Study. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7bE015BE8A-0000-C315-BFDF-32186365C7B0%7d
- RG&E (2023). Climate Change Resilience Plan. https://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7b7034F38B-0000-C01D-813A-A73CEBB821BA%7d
- Rocky Mountain Power (2023). Utah Wildfire Mitigation Plan. https://pscdocs.utah.gov/electric/23docs/2303544/329969UTWldfrMtgtnPln202320259-25-2023.pdf
- Schellenberg, Josh and Lisa Schwartz (2024). Grid Resilience Plans: State Requirements, Utility Practices, and Utility Plan Template. https://emp.lbl.gov/publications/grid-resilience-plans-state
- Southern California Edison (2022). Climate Change Vulnerability Assessment. https://edisonintl.sharepoint.com/:b:/t/Public/TM2/EY7Wy9MCrcVGl7XKg_tczQoBM0k8RKtJhwvWlf6qxlJvbg?e=ptXS0i
- Tampa Electric (2022). 2022–2031 Storm Protection Plan. https://www.floridapsc.com/library/filings/2022/11038-2022/11038-2022.pdf
- United Illuminating (2022). Evaluation of UI's Resilience Programs. https://www.dpuc.state.ct.us/DOCKCURR.NSF/8e6fc37a54110e3e852576190052b64d/d3b44da492184a1285258bd30063f5d0/$FILE/98991730.pdf/Exh%20UI-CIP-10.pdf
- Xcel Energy Minnesota (2019). Integrated Distribution Plan (2020-2029). https://www.xcelenergy.com/staticfiles/xe-responsive/Company/Rates%20&%20Regulations/IntegratedDistributionPlan.pdf

GRID DEPLOYMENT OFFICE

Berkeley Lab's new report, *Grid Resilience Plans: State Requirements, Utility Practices, and Utility Plan Template*



Resilience Plan Template

States and utilities can adapt this template to account for jurisdiction-specific considerations. A Word document version is available on Berkeley Lab's website for this purpose.

Section 1. Executive Summary

- Resilience plan objectives and motivation
  - Legislative and regulatory requirements
  - Extreme weather events, increasing restoration costs, availability of government funding support, data sources and solutions, technological changes, and other jurisdiction-specific items
- Definition of resilience, resilience event, and reliability – for example:
  - *Resilience* – "[A]bility to prepare for and adapt to changing conditions and withstand and recover rapidly from disruptions. Resilience includes the ability to withstand and recover from deliberate attacks, accidents, or naturally occurring threats or incidents."[1]
  - *Resilience event* – "[A]n event involving extreme weather conditions, wildfires, cybersecurity threats, or physical security threats that poses a material risk to the safe and reliable operation of an electric utility's transmission and distribution systems. A resiliency event is not primarily associated with resource adequacy or an electric utility's ability to deliver power to load under normal operating conditions."[2]
  - *Reliability* – "The ability to maintain the delivery of electric power to customers in the face of routine uncertainty in operating conditions."[3]
- Definitions of other key terms,[4] including those that define what the plan does (and does not) cover in terms of the service territory, infrastructure areas, etc.
- Hazards in scope
  - Summary of all hazards considered and ultimately selected during plan development
  - Brief rationale for any hazards that were not included in the vulnerability assessment

Page 1 of 9

- Template facilitates development of resilience plan requirements and assists with review of prepared plans
- Offers a standard format states can adapt, using the editable Word document version (reduces burden of review)
- Report and template available at this link: https://emp.lbl.gov/publications/grid-resilience-plans-state

GRID DEPLOYMENT OFFICE

Contact

https://www.energy.gov/gdo/grid-deployment-office

Josh Schellenberg JSchellenberg@lbl.gov

Lisa Schwartz, Berkeley Lab
https://emp.lbl.gov/
lcschwartz@lbl.gov
510-926-1091

Disclaimer

Copyright Notice

GDO GRID DEPLOYMENT OFFICE