Microgrids Proceeding R.19-09-009
Value of Resiliency

Resiliency Standards: Definitions and Metrics
Lumen Energy Strategy – Climate Resilience in Integrated Resource Planning

Grid Resiliency and Microgrids Team, Energy Division

March 21, 2023

California Public
Utilities Commission

WebEx and Call-In Information

Join by Computer:

https://cpuc.webex.com/cpuc/onstage/g.php?MTID=e350be82bbcf09a4a644bc6fa997e15a8

Event Password: GRMG (case sensitive)

Meeting Number: 2498 212 1418

Join by Phone:

- Please register using WebEx link to view phone number.

(Staff recommends using your computer's audio if possible.)

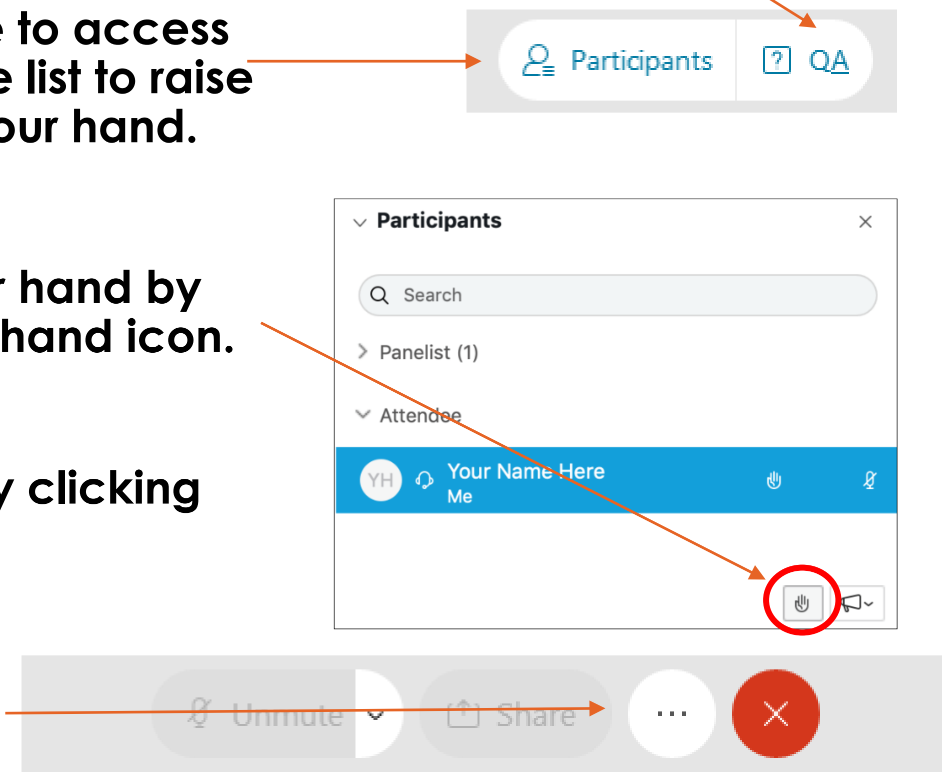
Notes:

- Today's presentations are available in the meeting invite (follow link above) and will be available shortly after the meeting on https://www.cpuc.ca.gov/resiliencyandmicrogrids.
- The presentation portion of this meeting will be recorded and posted on https://www.cpuc.ca.gov/resiliencyandmicrogrids.
- While one or more Commissioners and/or their staff may be present, no decisions will be made at this meeting.

WebEx Logistics

- All attendees are muted on entry by default.
- Questions can be asked verbally during Q&A segments using the “raise hand” function.
    - The host will unmute you during Q&A portions [and you will have a maximum of 2 minutes to ask your question].
    - Please lower your hand after you’ve asked your question by clicking on the “raise hand” again.
    - If you have another question, please “re-raise your hand” by clicking on the “raise hand” button twice.
- Questions can also be written in the Q&A box and will be answered verbally during Q&A segments.

WebEx Tip



Access the written Q&A panel here

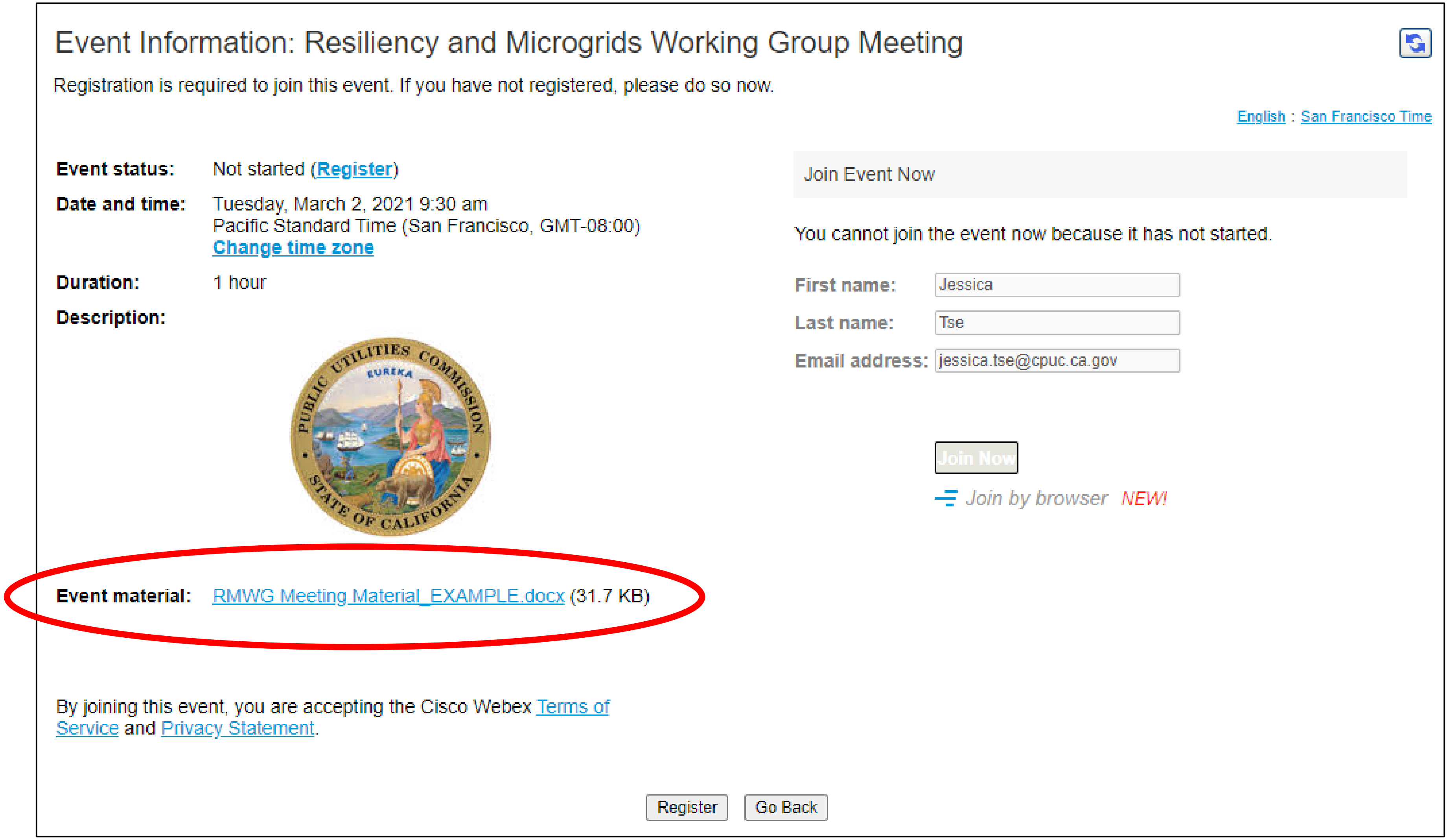
1. Click here to access the attendee list to raise and lower your hand.

2. Raise your hand by clicking the hand icon.

3. Lower it by clicking again.

Access your meeting audio settings here

WebEx Event Materials



Event Information: Resiliency and Microgrids Working Group Meeting

Registration is required to join this event. If you have not registered, please do so now.

English : San Francisco Time

Event status: Not started (Register)

Date and time: Tuesday, March 2, 2021 9:30 am
Pacific Standard Time (San Francisco, GMT-08:00)
Change time zone

Duration: 1 hour

Description:

Event material: RMWG Meeting Material_EXAMPLE.docx (31.7 KB)

By joining this event, you are accepting the Cisco Webex Terms of Service and Privacy Statement.

Join Event Now

You cannot join the event now because it has not started.

First name: Jessica

Last name: Tse

Email address: jessica.tse@cpuc.ca.gov

Agenda

I.	Introduction, CPUC Staff	1:00p – 1:05p
	• WebEx logistics, agenda review	
II.	Opening Remarks, Commissioner Shiroma	1:05p – 1:10p
III.	Framing the Conversation: Review of 4-Pillar Methodology, CPUC Staff	1:10p – 1:20p
IV.	Climate Resilience in Integrated Resource Planning, Lumen Energy Strategy	
	• Motivation and Opening Discussion	1:20p – 1:40p
	• Resiliency Definitions – Literature Review	1:40p – 2:15p
	• Stakeholder Brainstorming – Q&A	2:15p – 2:55p
	BREAK	2:55p – 3:00p
	• Climate Resilience in Integrated Resource Planning (IRP)	3:00p – 3:35p
	Q&A	3:35p – 3:45p
VI.	Closing Remarks, Adjourn	3:45p – 4:00p
	• Wrap-up	
	• Commissioner Closing Remarks	

Opening Remarks, Commissioner Shiroma

Background on the Microgrids Proceeding (R.19-09-009)

SB 1339 (2017-18) requires the CPUC, in cooperation with CEC and CAISO, to facilitate the commercialization of microgrids for distribution customers of large electrical corporations.

- Sept. 2018: SB 1339 signed by Governor
- Sept. 2019: OIR Issued by CPUC (R.19-09-009)
- Brief proceeding history
    - Track 1 (June 2020) – accelerate resiliency projects in response to wildfire/PSPS, PG&E Community Microgrids Enablement Program and Tariff (CMEP/CMET), PG&E temporary generation to mitigate outages due to PSPS
    - Track 2 (January 2021) – revisions to IOU electric rules to facilitate more complex microgrids, Microgrids Incentive Program (MIP) to support in-front-of-meter microgrids
    - Track 3 (July 2021) – suspend capacity reservation component of standby charge for highly utilized (85%) and available (95%) microgrids that meet CARB distribution generation criteria air pollution standards
    - Track 4 (in progress) – finalize MIP and consider tariff for multi-property microgrids
    - **Track 5 (in progress) – define and assess the value of resiliency to inform investments in resiliency strategies**

Workshop Series on the Value of Resiliency

- **Workshop #1**: Economic and Equity Impacts of Large Disruptions – May 10, 2022
  - To discuss the components behind the Interruption Cost Estimate (ICE) calculator and the Power Outage Economic Tool (POET)
- **Workshop #2**: Economic and Equity Impacts of Large Disruptions – July 7, 2022
  - To discuss the Social Burden Index and ReNCAT tools
- **Workshop #3**: Resiliency Standards: Definitions and Metrics – March 21, 2023
  - To explore resiliency definitions and how these definitions may be applied to integrating resiliency in a broader grid planning perspective
- **Future Workshops TBD**

More information available at: https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/resiliency-and-microgrids/resiliency-and-microgrids-events-and-materials

Framing the Conversation: Review of 4-Pillar Methodology

4-Pillar Methodology – Guiding Principles in Resiliency Valuation

I. **Baseline Assessment**
  - What/Whom do we want to protect and where is it/are they?
  - What threatens it/them?
  - How well are we doing now to protect it/them?

II. **Mitigation Measure Assessment**
  - What protection options do we have?
  - What does the best job at protecting the most?
  - What does it cost?

III. **Resiliency Scorecard** – scoring resiliency configuration characteristics including those that support State policy goals

IV. **Resiliency Response Assessment (post-disruption or modeling)** –
  - How well did the investments do in reaching resiliency targets?
  - Did the investments reduce impacts on the community?

Framing the Conversation: Review of 4-Pillar Methodology

4-Pillar Methodology – Guiding Principles in Resiliency Valuation

- Scalable, Sequential, Iterative methodology intended to provide a "check-list" to concepts that when used iteratively provide guidance toward continued improvement over development cycles.

- In this and future workshops we'll be looking at the application of these concepts from 3 different use case perspectives:
    - Grid planning
    - Project level
    - Problem level

WARP to Resilience

Weather-Adapted Resource Planning

Climate Resilience in Integrated Resource Planning

RESILIENCE DEFINITIONS, METRICS, AND THEIR USE IN GRID PLANNING AND INVESTMENT

Prepared for:

CPUC Microgrids Proceeding (R.19-09-009) Stakeholders

Prepared by:

Mariko Geronimo Aydin
Onur Aydin

Lumen ENERGY STRATEGY

March 21, 2023

Image credit: Cecilia Wessels/Facebook

“I was keeping an eye on it.”

WARP to Resilience

Weather-Adapted Resource Planning

Institutional Barrier		Advancement
No common definition of resilience or specific resilience evaluation metrics	❯	**Build a resilience framework** that includes a definition of resilience and resilience evaluation metrics
Planning models have several concerning disconnects from climate projections and climate-driven risks	❯	**Re-parameterize inputs and assumptions** to the state's resource planning models to account for climate-driven risks and extremes
Planning models are not structured to explicitly evaluate resilience	❯	**Develop a resilience evaluation model** that is open-source and evaluates input resource portfolios and plans
Planners and stakeholders have no in-hand assessment of the resilience of alternative optimal resource portfolios	❯	**Conduct a resilience assessment** of the state's resource portfolios and plans (e.g., Preferred System Plan)

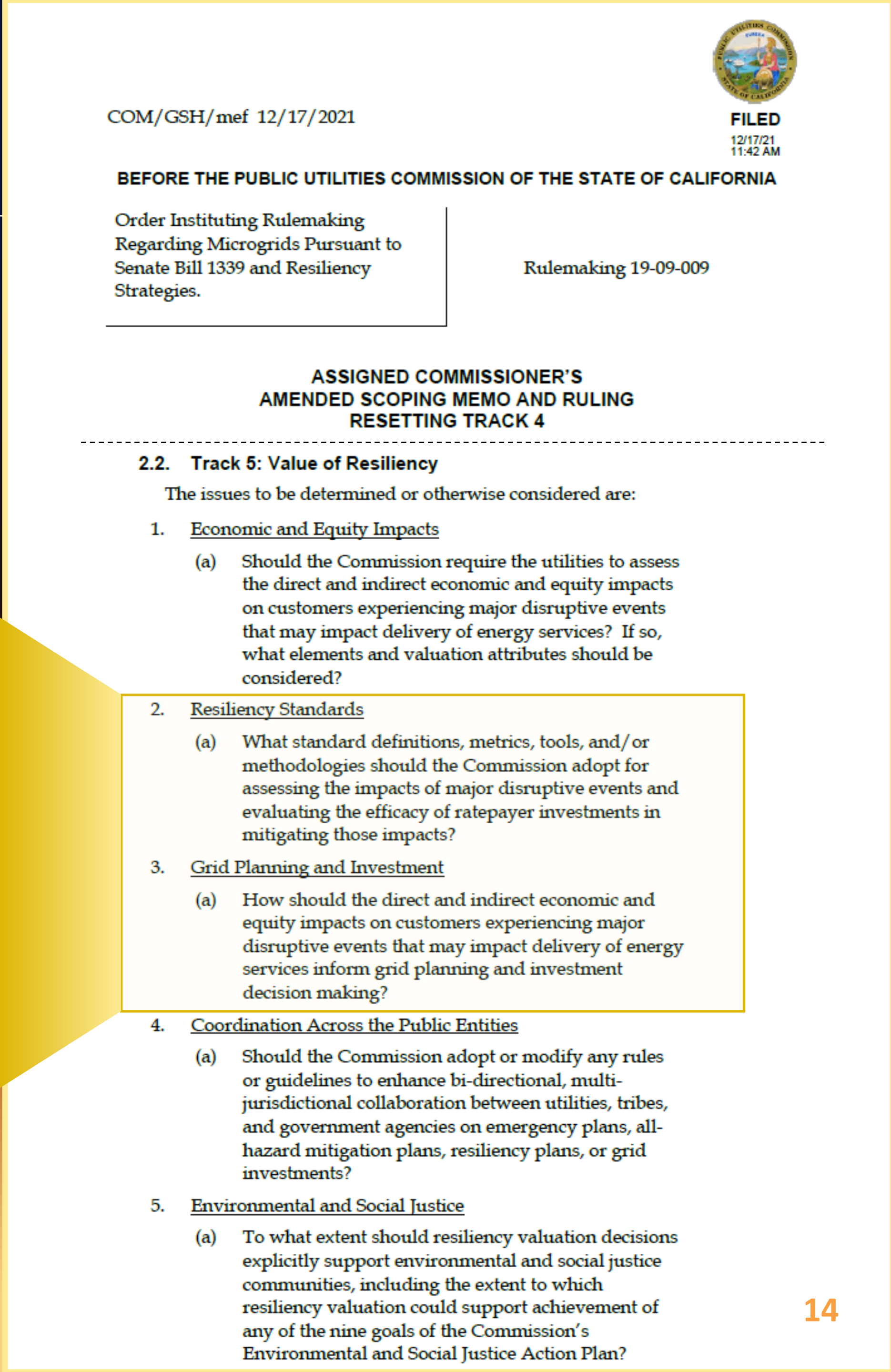
Key issues

- **Resiliency Standards**

  What standard definitions, metrics, tools, and/or methodologies should the Commission adopt for assessing the impacts of major disruptive events and evaluating the efficacy of ratepayer investments in mitigating those impacts?

- **Grid Planning and Investment**

  How should the direct and indirect economic and equity impacts on customers experiencing major disruptive events that may impact delivery of energy services inform grid planning and investment decision making?



COM/GSH/mef 12/17/2021

FILED
12/17/21
11:42 AM

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF CALIFORNIA

Order Instituting Rulemaking Regarding Microgrids Pursuant to Senate Bill 1339 and Resiliency Strategies.	Rulemaking 19-09-009

ASSIGNED COMMISSIONER'S
AMENDED SCOPING MEMO AND RULING
RESETTING TRACK 4

2.2. Track 5: Value of Resiliency

The issues to be determined or otherwise considered are:

1. Economic and Equity Impacts
   (a) Should the Commission require the utilities to assess the direct and indirect economic and equity impacts on customers experiencing major disruptive events that may impact delivery of energy services? If so, what elements and valuation attributes should be considered?
2. Resiliency Standards
   (a) What standard definitions, metrics, tools, and/or methodologies should the Commission adopt for assessing the impacts of major disruptive events and evaluating the efficacy of ratepayer investments in mitigating those impacts?
3. Grid Planning and Investment
   (a) How should the direct and indirect economic and equity impacts on customers experiencing major disruptive events that may impact delivery of energy services inform grid planning and investment decision making?
4. Coordination Across the Public Entities
   (a) Should the Commission adopt or modify any rules or guidelines to enhance bi-directional, multi-jurisdictional collaboration between utilities, tribes, and government agencies on emergency plans, all-hazard mitigation plans, resiliency plans, or grid investments?
5. Environmental and Social Justice
   (a) To what extent should resiliency valuation decisions explicitly support environmental and social justice communities, including the extent to which resiliency valuation could support achievement of any of the nine goals of the Commission's Environmental and Social Justice Action Plan?

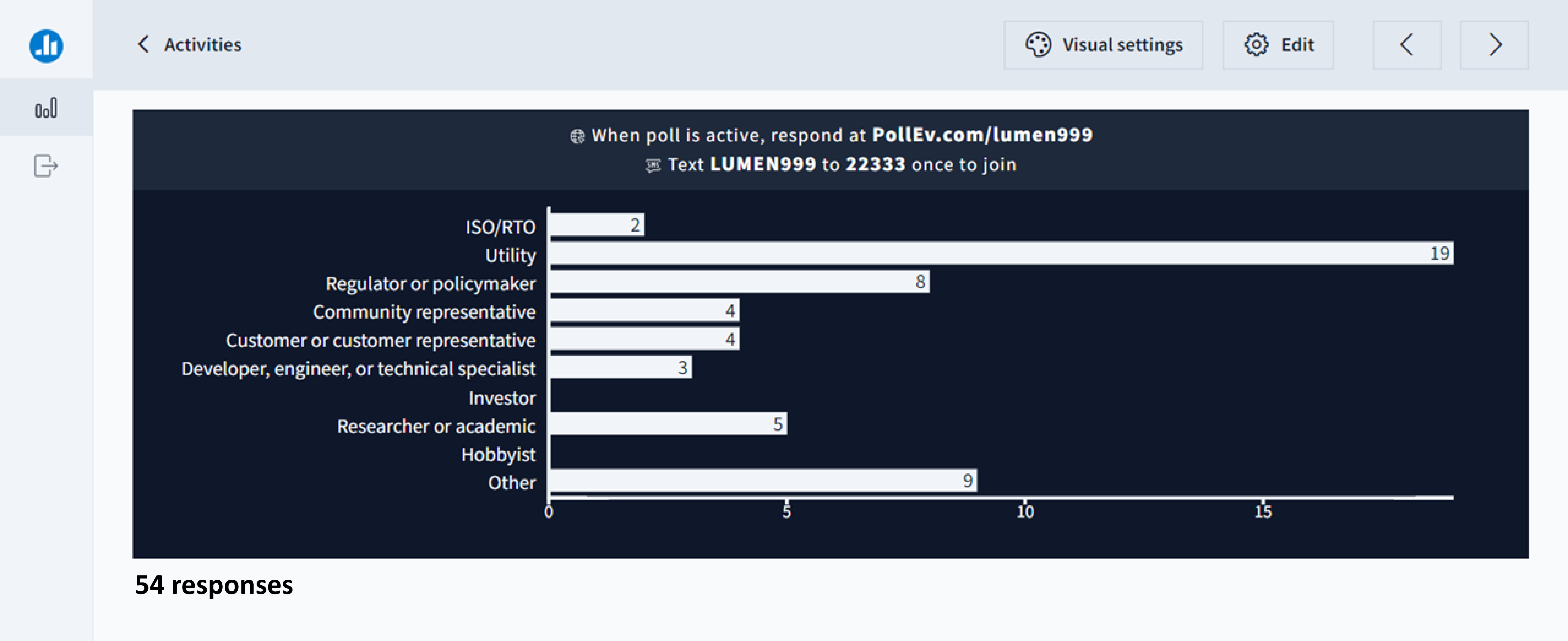
Goals of this workshop

- Share highlights from our research on **<u>key elements of a resilience definition</u>** that are broadly relevant as you explore resilience in your work

- Walk through our process for **<u>refining the definition of resilience</u>** so tangible resilience metrics and decision points can be developed and designed into grid planning processes
  - What is the function (or service) to be made resilient, and what is the system behind that function?
  - What are the hazards threatening resilience, what do we know of their risk profiles, and where are the system failure points?

- **<u>Engage discussion</u>** to explore resilience objectives and key issues in this proceeding

What stakeholder perspective best describes you?



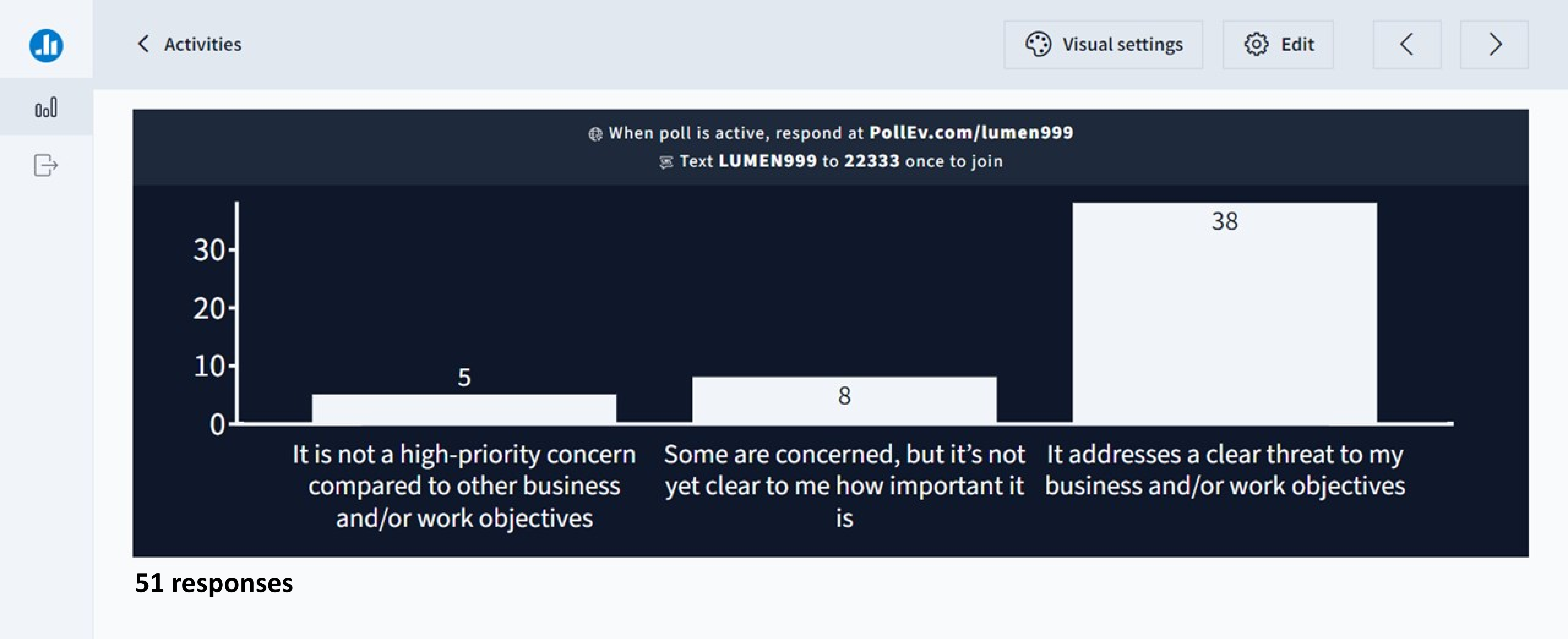
When poll is active, respond at **PollEv.com/lumen999**

Text **LUMEN999** to **22333** once to join

54 responses

In your job and/or immediate area of work:

How important is resilience planning?



When poll is active, respond at **PollEv.com/lumen999**

Text **LUMEN999** to **22333** once to join

51 responses

In your job and/or immediate area of work:

What best describes current resilience planning practices?

When poll is active, respond at **PollEv.com/lumen999**
Text **LUMEN999** to **22333** once to join

None (or not applicable); we have not adopted any resilience-specific planning practices	15%
Limited; resilience is considered but only within our status quo planning practices	9%
Emerging; we have expanded some aspects of our planning practices to better address resilience	68%
Advanced; we have made foundational changes to our planning processes to incorporate resilience	8%

53 responses

What is the greatest barrier or challenge to effective resilience planning?

When poll is active, respond at **PollEv.com/lumen999**

Text **LUMEN999** to **22333** once to join

79 responses

(multiple responses allowed; approximately 2 responses per person)

SURVEY OF USE OF “RESILIENCE” IN ENERGY INDUSTRY

Research approach and purpose

We reviewed a broad range of industry literature discussing what resilience means

- ~60 documents/articles reviewed; including perspectives from federal and state regulators, system operators, utilities, think tanks; including descriptions and assessments of multiple resilience-related events across the U.S. and in California

We won’t cover everything in this presentation, but will summarize and look at it from a few different angles in order to:

- Highlight key resilience concepts and elements of a resilience definition
- Identify what aspects of resilience we must define more specifically in order to apply the IRP use case
  - *For more information see 4 Pillars: I. Baseline Assessment*
  - *See also selected references at the end of this presentation*

You can’t manage what you don’t measure …

… and you can’t measure what you don’t define

Federal definitions of resilience

PRIOR CONTEXT

Communications security

Cybersecurity

Energy security

NIAC The President's National Infrastructure Advisory Council

2009

"Infrastructure resilience is the ability to reduce the magnitude and/or duration of disruptive events. The effectiveness of a resilient infrastructure or enterprise depends upon its ability to anticipate, absorb, adapt to, and/or rapidly recover from a potentially disruptive event."

PRESIDENTIAL POLICY DIRECTIVE/PPD-21

SUBJECT: Critical Infrastructure Security and Resilience

2013

"The term 'resilience' means the ability 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."

Grid Resilience in Regional Transmission Organizations and Independent System Operators

AD18-7-000

2018

"The ability to withstand and reduce the magnitude and/or duration of disruptive events, which includes the capability to anticipate, absorb, adapt to, and/or rapidly recover from such events."

NREL

Resilience Roadmap: A Collaborative Approach to Multi-Jurisdictional Resilience Planning

2019

"The ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions through adaptable and holistic planning and technical solutions."

Themes in federal definitions

Federal definitions of resilience indicate some refinement, and some ambiguities that pose challenges to application and decision-making

Initial concepts we see emerge:

- Evolving from 2009 NIAC report, a better distinction between the **hazard/event** and the **system** that needs to be resilient against it
  - Reduce magnitude of events > withstand and reduce magnitude of events > withstand, respond to, and recover rapidly from events
- Consistency on what the resilient system does: **withstand, absorb, recover from, adapt to**


Image credit: Joe Raedle/Getty Images.

- Implied the system performs some **critical function**, although exact function not specified
  - Distinction between "critical infrastructure" and "community resilience"
- Implied that **hazard/event is uncontrollable** and disruptive to the system, although neither hazard nor its severity are specified
  - "disruptions" vs. "changing conditions" vs. "deliberate attacks, accidents, or naturally occurring threats or incidents"
  - However, through this timeline we see a growing record and prominence of weather-driven events as hazards to the energy system

State perspectives

NARUC
National Association of Regulatory Utility Commissioners

Public Utilities Commission State of California

Microgrids and Resiliency Staff Concept Paper
R.19-09-009

NASEO
National Association of State Energy Officials

2013

"…robustness and recovery characteristics of utility infrastructure and operations, which **avoid or minimize interruptions of service during an extraordinary and hazardous event**."

2020

"…the **ability to mitigate the impact of a large, disruptive event** by any one or more of the following mechanisms:

1. Reducing the magnitude of disruption;
2. Extending the duration of resistance;
3. Reducing the duration of disruption;
4. Reducing the duration of recovery."

2022

"…expenditures have been guided by imprecise approaches that fail to account for the **impacts of outages** or anticipate [high-impact low-frequency] events such as Winter Storm Uri"

"New approaches to analyzing the costs and benefits of resilience investments, such as microgrids, can enable more efficient use of ratepayer and taxpayer resources to deliver better outcomes."

- Clearer descriptions of key hazard/event characteristics
- Clearer identification of objectives and/or undesired outcomes
- Recognition of need to analyze costs and benefits of resilience investments

A public power perspective

TVA

—Highlights community-centric focus

"…how to prepare for and respond to events that **affect infrastructure beyond design standards**."

Riverside

—Highlights processes and roles during an emergency

"…how to prepare for the emergencies that may happen, how to address the emergency while and immediately after it occurs, and then how to recover."

AMERICAN PUBLIC POWER ASSOCIATION

2021

"…How well an electric utility (or system of utilities) can absorb **an event that causes an outage** in all or parts of its territory and restore power as quickly as possible."

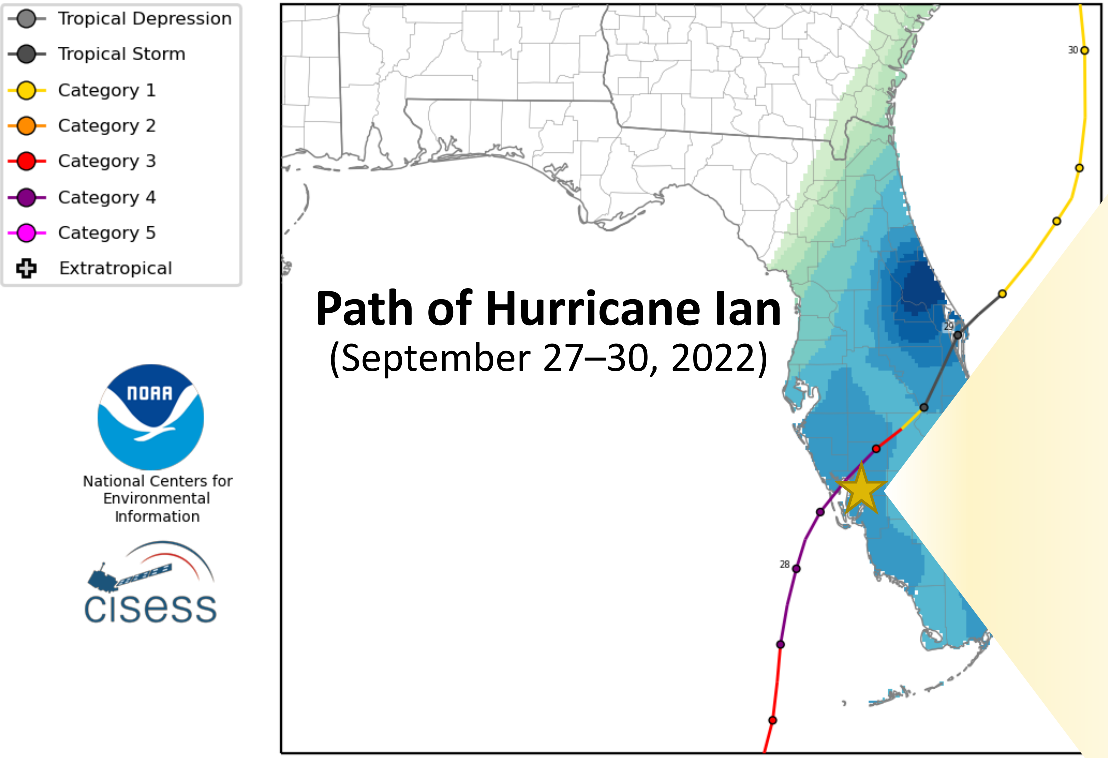
Names the scope of hazards, as "high-impact, low frequency" events, objectives including cyber and physical security

- Also more specific about the hazard/event, objectives or undesired outcomes
- Demonstrates diversity in local preferences and varying degrees of focus on mitigation and adaptation (reducing risk) versus emergency preparedness and recovery (managing the unavoidable residual risk)

What does resilience look like?

Home named Sand Palace (foreground) with surrounding structures demolished by Hurricane Michael in 2018.
Image credit: Johnny Milano/The New York Times/Redux

What critical function(s) does the system serve?



Path of Hurricane Ian
(September 27–30, 2022)

National Centers for Environmental Information

cisess

Image credit: NOAA/NCEI/NHC.

Home » News » Local » Charlotte County » Babcock Ranch weathers Ian, never losing electricity, internet or water

Babcock Ranch weathers Ian, never losing electricity, internet or water

by **Evan Dean** — 2:23 PM EDT, Sat October 15, 2022

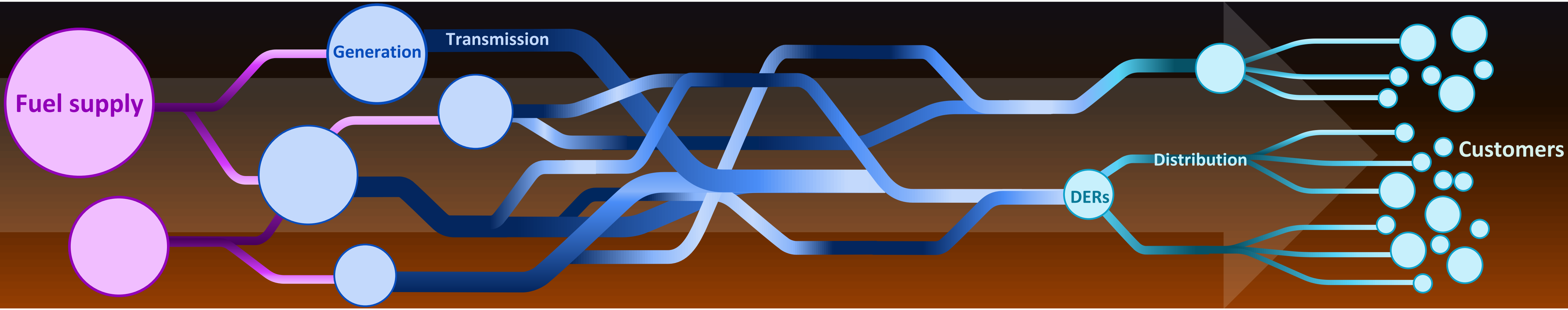
Image credit: NBC-2, Waterman Broadcasting of Florida, LLC

What is the critical function or service?

In the context of electricity system planning:

- Electricity service that meets the essential needs of people and communities, even during an emergency
  - Priority and critical loads: insufficient electricity will result in secondary impacts of interruptions of other types of essential functions/services needed for survival (e.g., water, food, communications, transportation/egress, relief from life-threatening temperatures, medical)
- Undesired outcome is inaccessibility of electricity when needed for survival and livelihood
  - Outage at the point of consumption
  - Worsened by lack of substitution when outages extend in time or space (e.g., cannot go to neighbor or community center for relief)
  - Worsened when hazard is life-threatening in itself and/or threatens other essential services

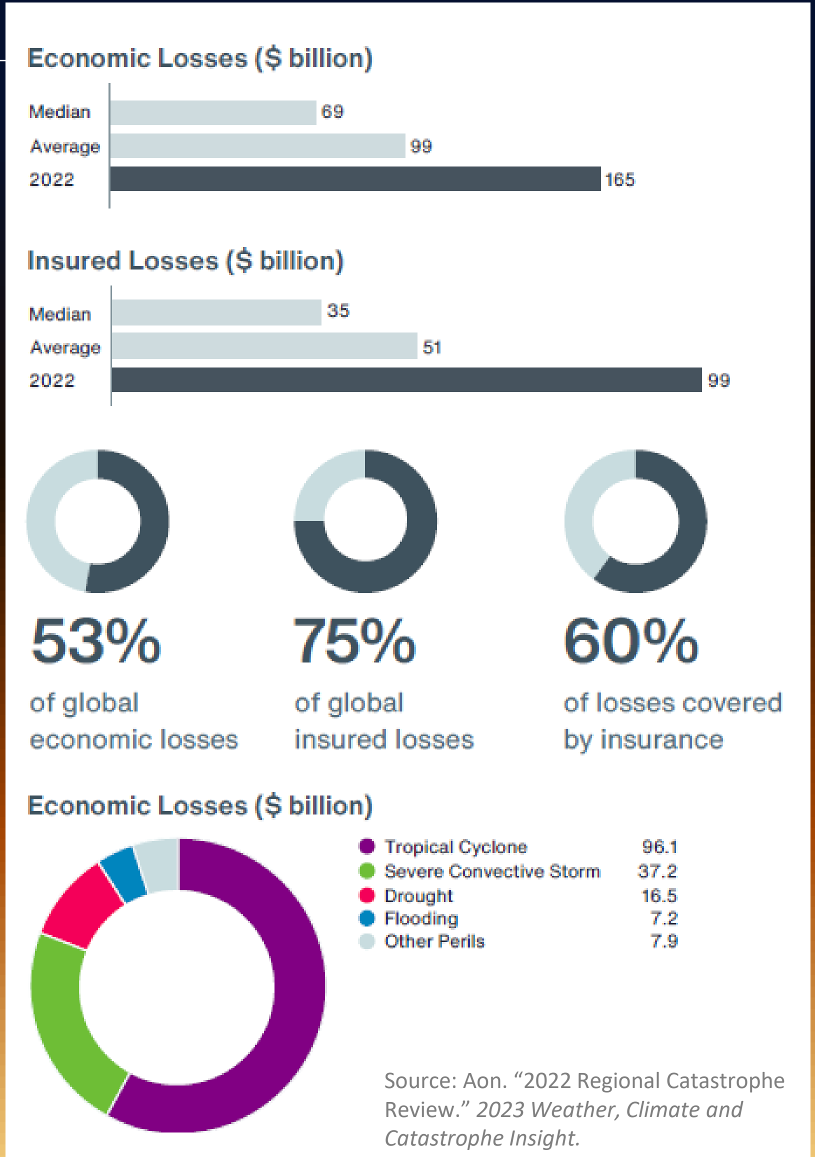
What is the system providing critical service?



What are the hazards?

- Economy-wide: tropical cyclones, convective storms, drought, and flooding are major sources of measured losses
- Weather-related trends and extremes continue to test our systems with conditions beyond our system planning view
- Hazards specifically to electricity infrastructure and electricity service are consistent with this view, but with an even broader set of threats

Major sources of economic losses in the United States, 2022



Source: Aon. “2022 Regional Catastrophe Review.” *2023 Weather, Climate and Catastrophe Insight.*

NATIONALLY, HURRICANES ARE AMONG THE MOST DESTRUCTIVE TO THE ELECTRICITY GRID

HURRICANES IRMA AND MARIA (2017)

In PR, 1.2MM (75%) households on outage for more than a month; some for almost a year; intermittent outages since

Most destruction at distribution and customer level

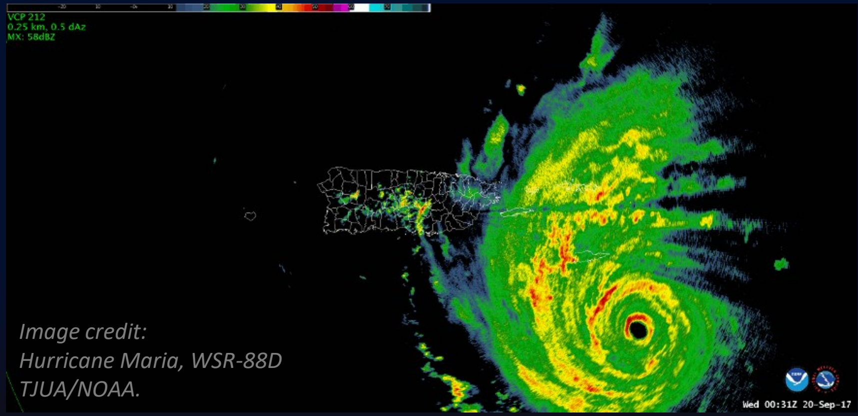
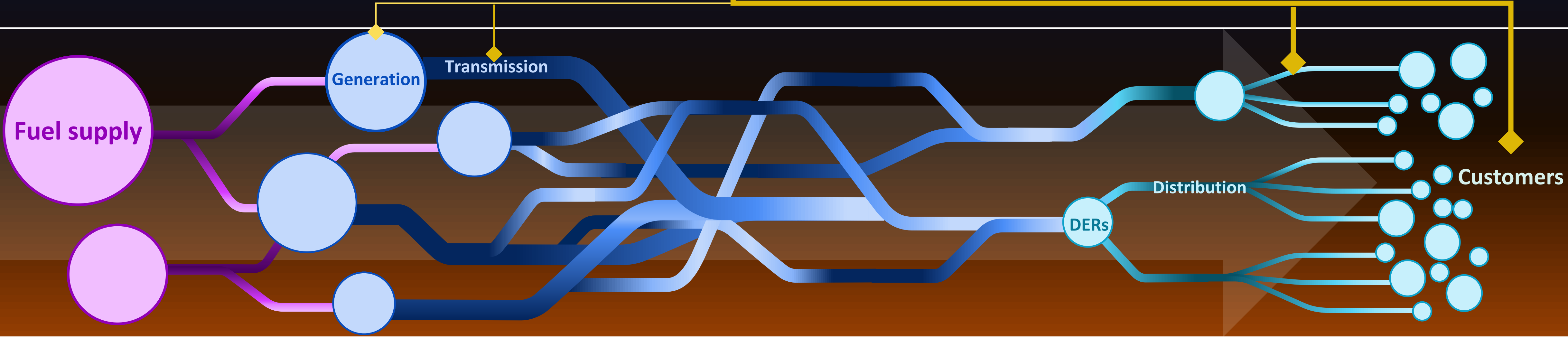


Image credit: Hurricane Maria, WSR-88D TJUA/NOAA.



HURRICANE KATRINA (2005)

Highest cost disaster on record (NOAA, 2023)

Image credit: history.com

HURRICANE HARVEY (2017)

2nd costliest on record (NOAA, 2023)

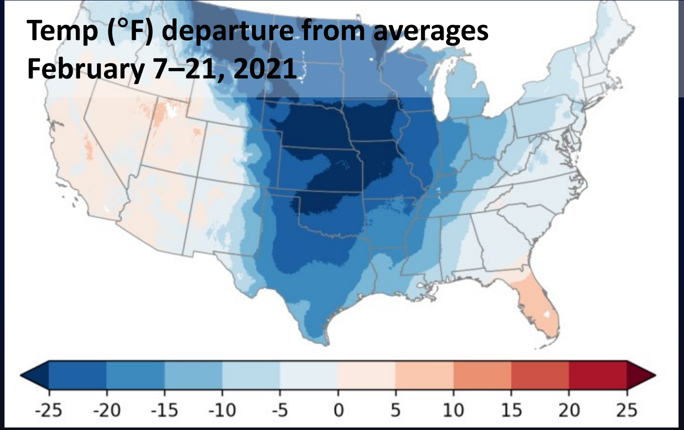
Image credit: Borenstein/AP

HURRICANE IAN (2022)

"2nd costliest natural disaster for insurers on record" (Aon, 2022)

Image credit: WJXT/clickorlando.com

Winter storms are also highly disruptive and hazardous



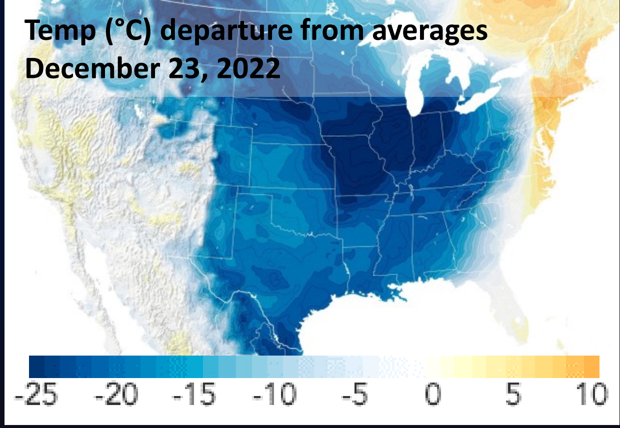
Temp (°F) departure from averages
February 7–21, 2021

Winter Storms Uri (2021) and Elliot (2022)

Uri the "largest controlled firm load shed event in U.S. history" (FERC); in TX, 69% people experienced an outage, days on average

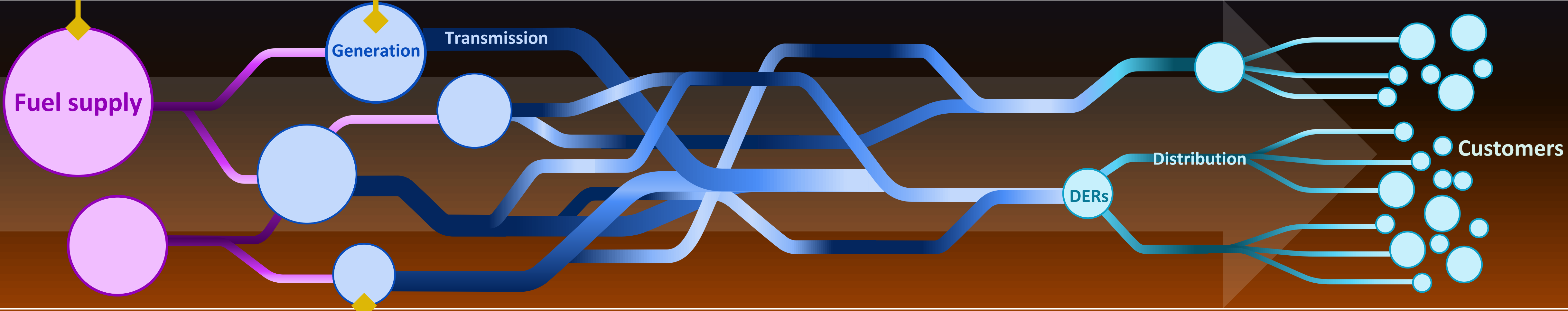
Sudden cold snap; peak demand under-forecasted by 14%; 30 GW weather-related generation outages

Extensive outages with Elliot; highlighted chronic issues and controversy over reliability standards



Temp (°C) departure from averages
December 23, 2022

Image credits: NOAA

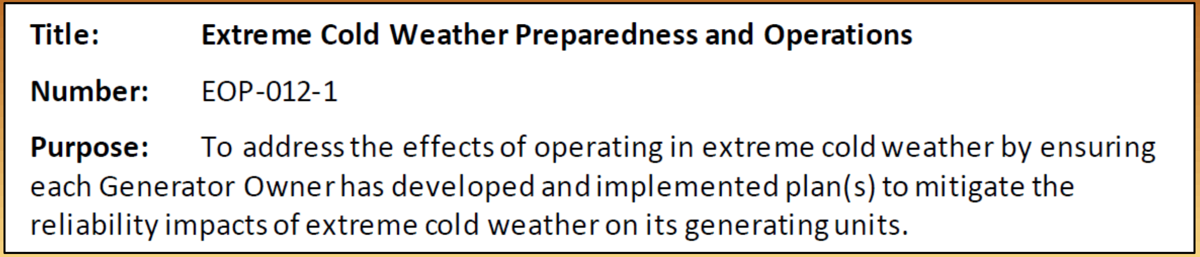


NERC's New Reliability Standards in EOP-012-1 (Extreme Cold Weather Preparedness and Operations)

Challenges in definition of specific "extreme cold weather temperature" thresholds for required freeze protections

Concerns about ambiguities in language to undermine the standards' effectiveness

Notably does not address fuel supply issues

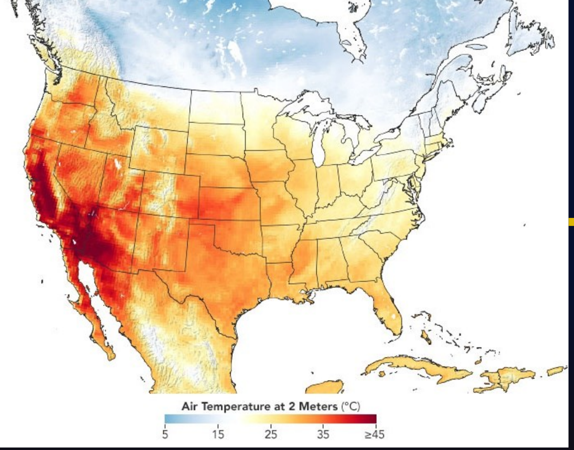


Title: **Extreme Cold Weather Preparedness and Operations**

Number: EOP-012-1

Purpose: To address the effects of operating in extreme cold weather by ensuring each Generator Owner has developed and implemented plan(s) to mitigate the reliability impacts of extreme cold weather on its generating units.

IN CALIFORNIA, KNOWN ENVIRONMENTAL HAZARDS IMPACT ALL PARTS OF THE GRID



WESTERN HEAT WAVE (2020)

Rotating blackouts in CA affecting hundreds of thousands of customers, lasting several hours

Near miss in 2022 with even higher temps in CA

EXTREME DROUGHT

Compounding factor

EXTREME WILDFIRES

(2007) 80k San Diego customers on outage, some for weeks, due to damage on Southwest Powerlink transmission

(2019) Multiple day outages due to PSPS, affecting millions of customers + Saddleridge fire severely impacting transmission into LADWP

COLD SNAP, TBD

Is CA's natural gas system vulnerable to cold snaps?

EXTREME SMOKE (2020)

Near miss when smoke tripped 4,000 MW California-Oregon Intertie, forcing 1,500 MW of de-rate on Pacific DC Intertie

STORMS, FLOODS (2022/23)

Rain, snow, wind, floods, mudslides

Full outage extent tbd; likely >= hundreds of thousands of people, lasting days

Image notes and credits, clockwise from top left: September 6, 2020 temperatures across California (NASA/Joshua Stevens); Lake Oroville in 2020 (AP/Ethan Swope); 2021 Caldor fire (AP/Ethan Swope); vehicle in flood water during 2022/23 winter storms in California (Robert Tong/Marin Independent Journal); downed tree from 2022/23 winter storms in California (Sara Nevis/AP); person shoveling snow from 2022/23 winter storms in California (Jae C. Hong/AP); smoke from 2020 August Complex fire (CNN/Harmeet Kaur).

Summary of elements of a resilience definition in the context of California’s grid planning

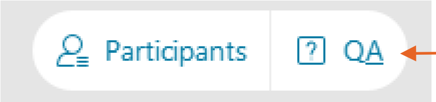
Key elements of a resilience definition	Application to California’s grid planning
What is the **critical function or service** that must be preserved?	Electricity service to end use customers, even under emergency conditions *Recognizing that some prioritization is needed in avoiding outages, e.g., priority and critical loads*
What is the **system** providing that function/service?	Electricity grid, including all grid domains, and from fuel supply to end use customer
What are the key **hazards** that can disrupt the systems’ ability to provide those functions/services?	Environmental and weather conditions that can significantly increase electricity demand, reduce electricity supply, or limit delivery of electricity to customers *Includes extreme heat/cold, drought, wildfires, storms, winds, floods, smoke*
Where are the known **failure points** on the system that would disrupt that function/service?	▪ Insufficient generation available to meet demand ▪ T&D wires outages and de-rates
What are the **most concerning sets of hazards & failure points**, reflecting risk tolerances on impact vs. probability?	▪ Temperature extremes on demand and supply ▪ Wildfire/smoke affecting distribution sections and key transmission corridors

AUDIENCE INPUT: ELEMENTS OF A RESILIENCE DEFINITION FOR GRID PLANNING

Discussion and Q&A

WebEx Tip

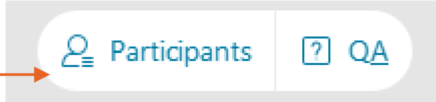
Option 1:



Access the written Q&A panel here

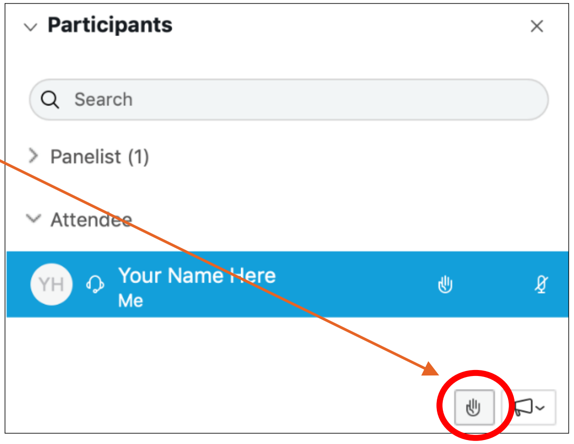
Option 2:

1. Click here to access the attendee list to raise and lower your hand.



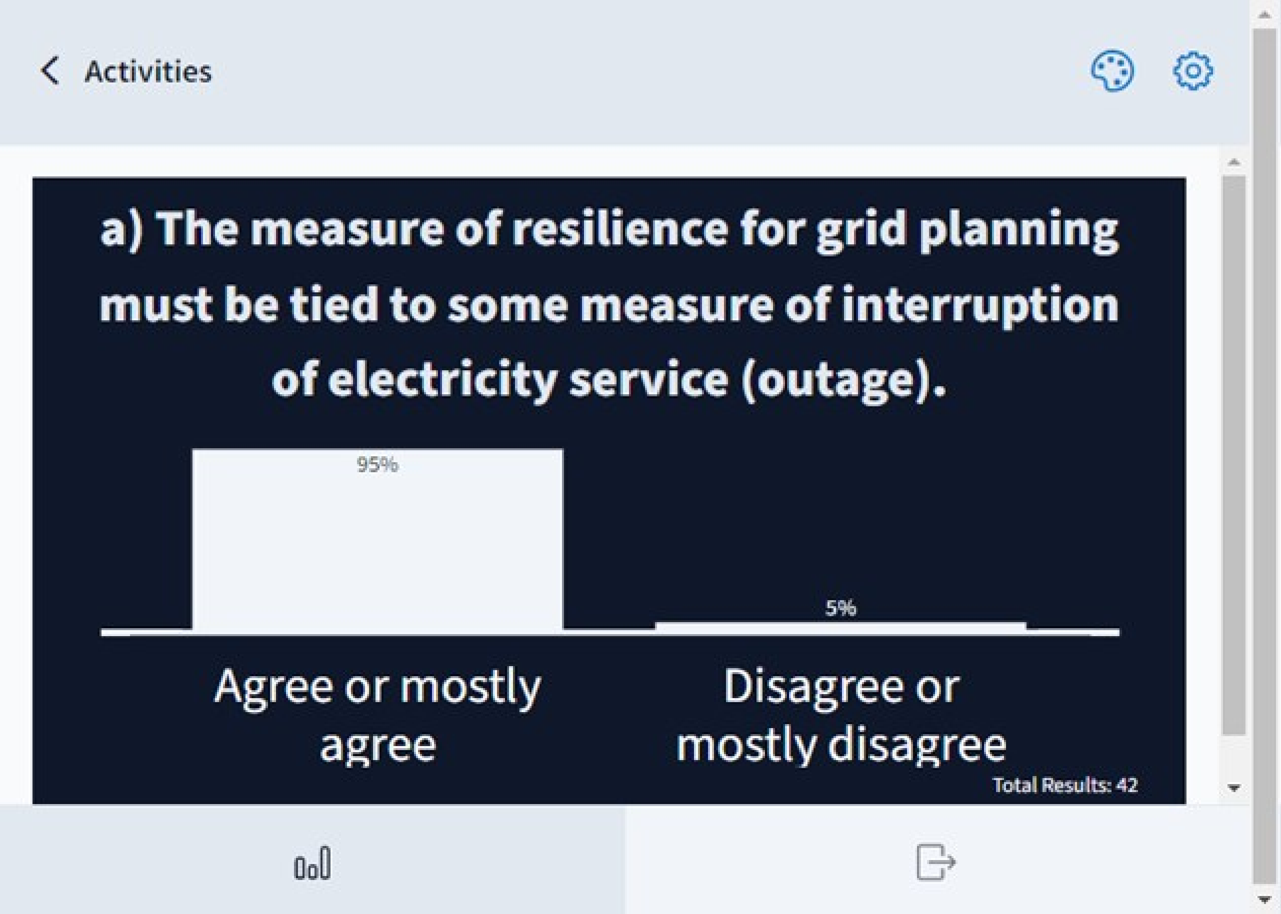
2. Raise your hand by clicking the hand icon.

3. Lower it by clicking again.



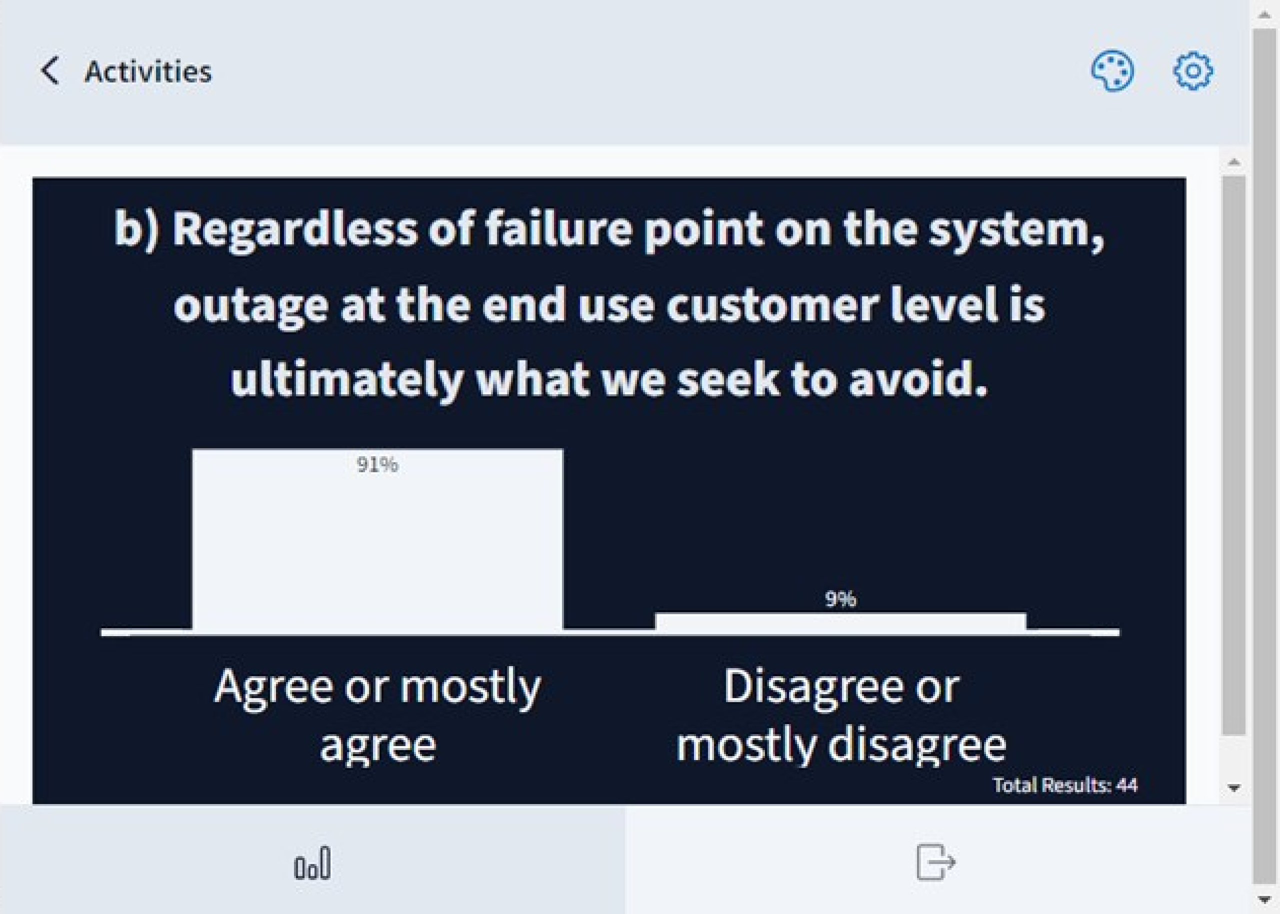
Do you agree/mostly agree or disagree/mostly disagree with these resilience definition elements for grid planning?

When each poll is active, respond at **PollEv.com/lumen999**
Text LUMEN999 to 22333 once to join, then **YES** or **NO**



a) The measure of resilience for grid planning must be tied to some measure of interruption of electricity service (outage).

Total Results: 42

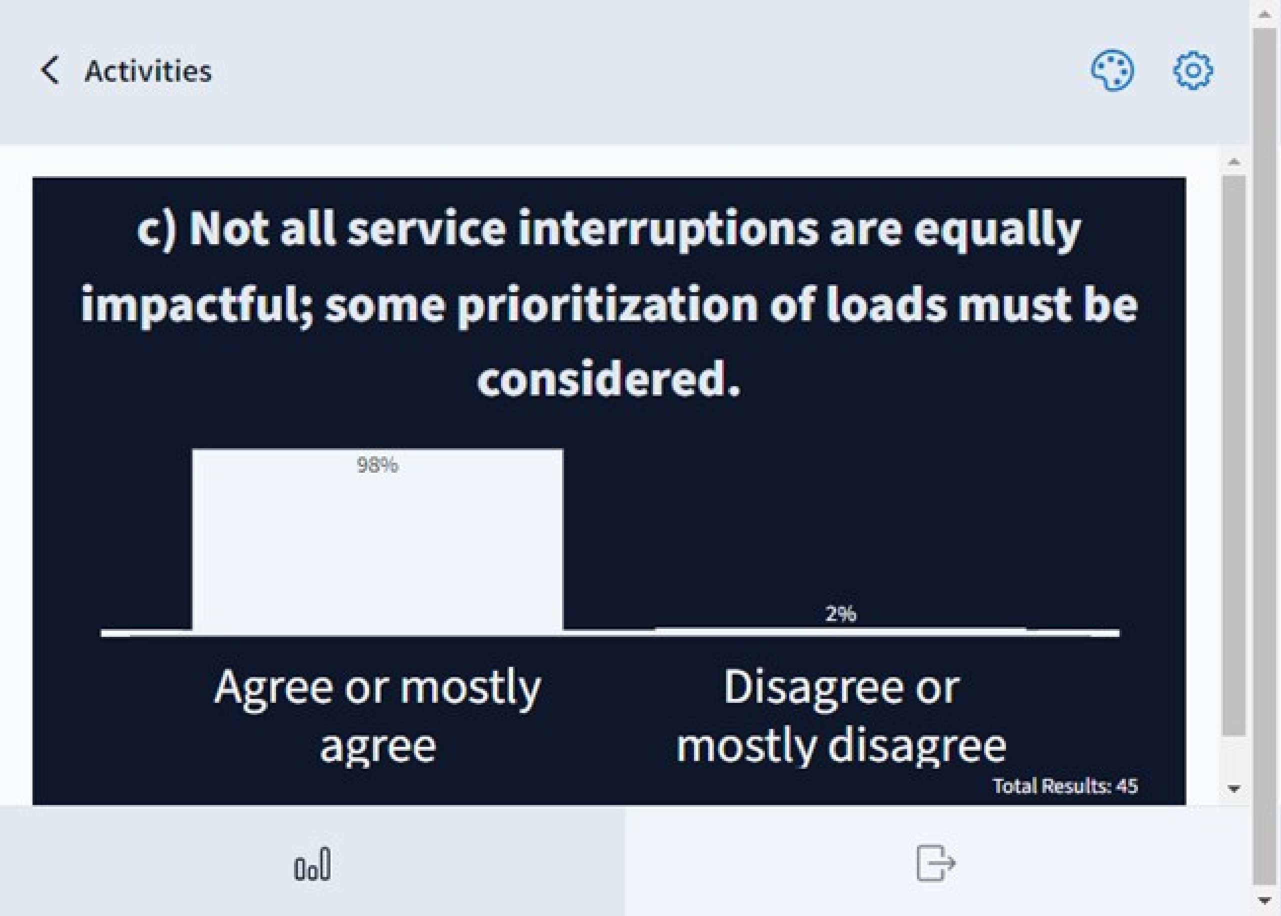


b) Regardless of failure point on the system, outage at the end use customer level is ultimately what we seek to avoid.

Total Results: 44

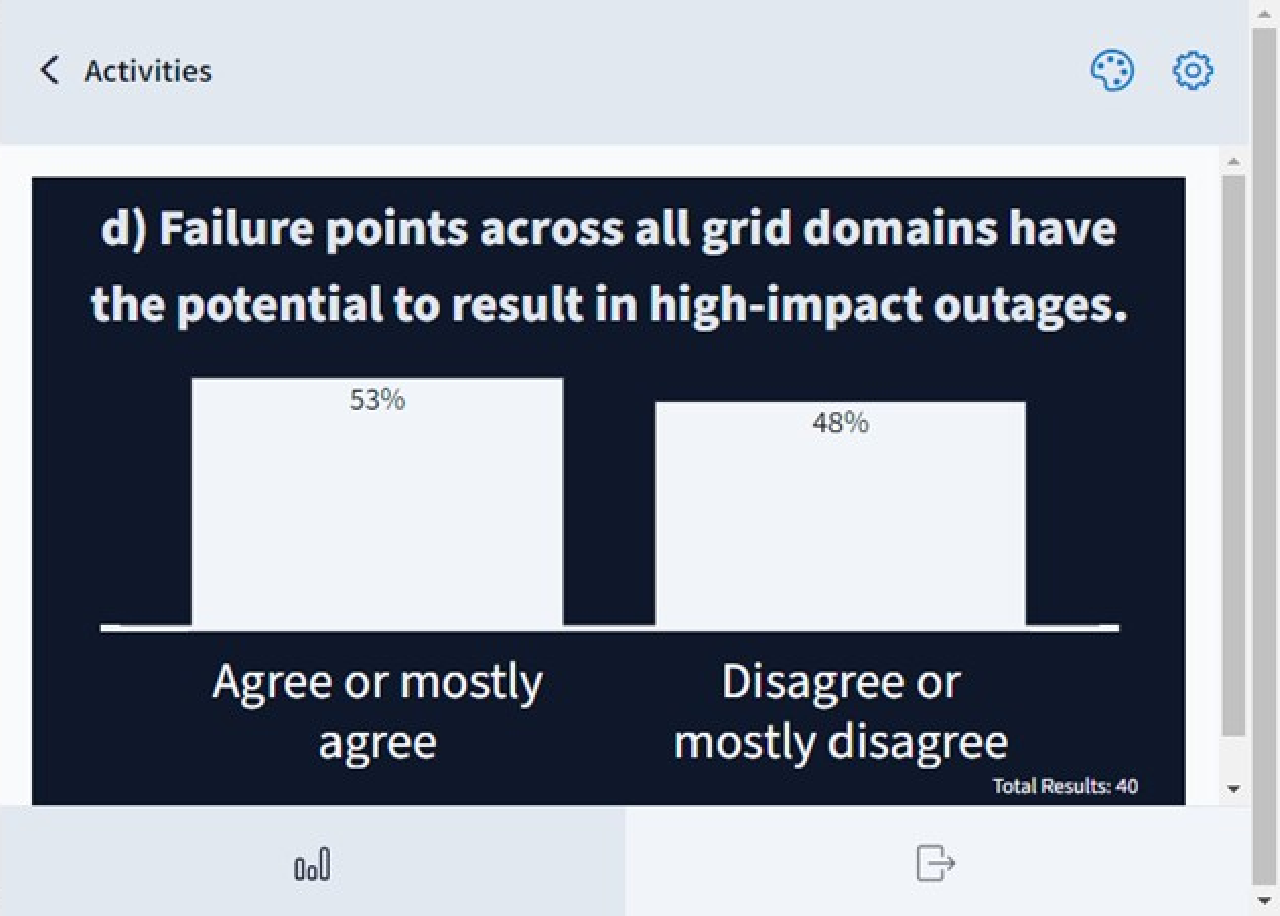
Do you agree/mostly agree or disagree/mostly disagree with these resilience definition elements for grid planning?

When each poll is active, respond at **PollEv.com/lumen999**
Text LUMEN999 to 22333 once to join, then **YES** or **NO**



c) Not all service interruptions are equally impactful; some prioritization of loads must be considered.

Total Results: 45



d) Failure points across all grid domains have the potential to result in high-impact outages.

Total Results: 40

Do you agree/mostly agree or disagree/mostly disagree with these resilience definition elements for grid planning?

When each poll is active, respond at **PollEv.com/lumen999**

Text LUMEN999 to 22333 once to join, then **YES** or **NO** for question (e), **string of words** for question (f)

e) The key known set of resilience hazards at the state grid planning level is weather/environmental variabilities, trends, and extremes.

Total Results: 40

f) What other resilience hazards must be considered in grid planning?

Total Results: 51

AUDIENCE BRAINSTORMING: FACTORS THAT WORSEN OUTAGE IMPACTS

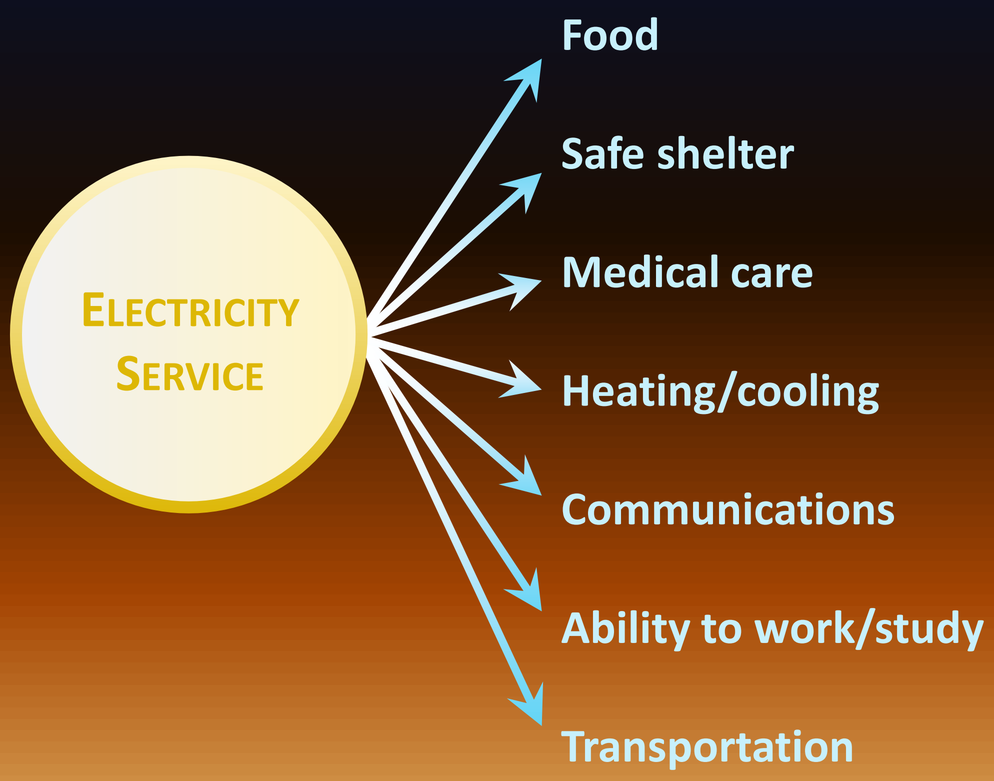
The heterogeneous impacts of outages

- We define electricity service as the key service to preserve but it’s more complicated than that.
- Why do we say that “not all service interruptions are equally impactful” and what does that mean for our resilience definition?
- Industry literature and experience shows us many ways outage impacts can be multiplied or worsened:
  - Outages affect customer classes differently
  - Within customer classes, differences in customers’ ability to withstand, adjust to, recover from outages
  - Outage characteristics and environmental conditions can have a multiplier effect on outage impacts (e.g., impacts from long-duration outage may be more than sum of two shorter outages)
- Challenge in grid planning: how do we weigh electricity service to reflect these differences?

Outages as an accessibility issue

- Another way to look at this is in terms of accessibility
- Electricity is really a mechanism to access other services needed for survival and livelihood
- Even in blue sky conditions, customers have unequal access to these elements of survival
  - Income/wealth and ability to have substitute resources on hand
- When the grid fails in some way, characteristics and circumstances of the outage can worsen individual customers’ accessibility in different ways and at different levels
- This perspective provides a framework for distinguishing the severity of impacts of an outage depending on characteristics and customer circumstances

**** See Sandia’s ReNCAT and Social Burden Metric***



ELECTRICITY SERVICE

Food

Safe shelter

Medical care

Heating/cooling

Communications

Ability to work/study

Transportation

Assuming an outage happens, what are the most important factors to consider in grid planning that impact accessibility to the critical services the electricity would have enabled (e.g., food, communications, heating/cooling, medical care)?

31	Outage duration
25	Whether the end-use customer provides critical services vs. consumes critical services (customer class, building type)
19	Concurrence of environmental/weather extremes (heat wave, cold snap, high wildfire threat)
17	Outage footprint (contiguous geographic area)
10	Accessibility of emergency services (e.g. cooling stations, emergency centers) and/or backup generation
10	Outage frequency
10	End-use customer financial power (wealth, income, ability to privately hold reserves/inventory)
9	essential services: for community continuity including emergency communications, water supply, wastewater treatment,
6	Pre-existing infrastructure and vulnerability of a community, related to community wealth, racial composition and burden of energy externalities.
6	Population vulnerability (elderly, children, disabled)
6	Outage notice
5	Geographic isolation (ability for surrounding regions to deliver support)
5	Cost/Benefit and cost effectiveness of alternatives
5	DER
4	Basic survival: Medical, shelter, heating, cooling, communication and ability to rotate service through a larger region.
3	As a part of End-User Customers: Critical infrastructure disruption (e.g. water, telecommunication, transportation, hospitals, emergency services)
3	Advance warning (vs totally unexpected)
3	End-use energy diversity (natural gas water heaters, stoves but NOT outage mitigation resources)
2	number of people affected
2	proximity to local services (banks, gas, food) that are not impacted by the outage
2	heating/cooling, communications, medical care, EV charging
2	Operating equipment safely
2	Penetration rate of back-up power adoption
2	Customer preparation/capacity expectation
2	Having enough redundant, dispatchable firm resources. Energy diversity in the form of electricity, gas, diesel, a little bit of everything, because if we are completely electrified and super clean, and we lose the grid, it's all your eggs in one basket with no options.
2	communication AFN medical water
2	End-use customer location and surrounding land use (remote vs. urban)
1	Time for crews to restore power
1	types of people affect in terms of vulnerability like age, health status
1	Outages can impact the ability to utilize natural gas appliances.
1	Resources available to customer
1	Dependent on weather: extreme heat, colds - temperature control. Critical facilities for medical care (medical device charging, clinics, insulin refrigeration)
0	EV charging during an emergency
-1	historical equity
-2	Rooftop solar not being able to access during an outage
-2	lighting, phone/laptop charging, food
-3	Source of outage

Entries included at the start of the poll

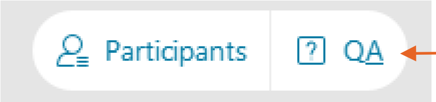
Entries added to the list by stakeholders

Values reflect net votes (👍 minus 👎)

Discussion and Q&A

WebEx Tip

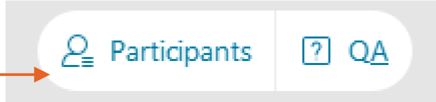
Option 1:



Access the written Q&A panel here

Option 2:

1. Click here to access the attendee list to raise and lower your hand.



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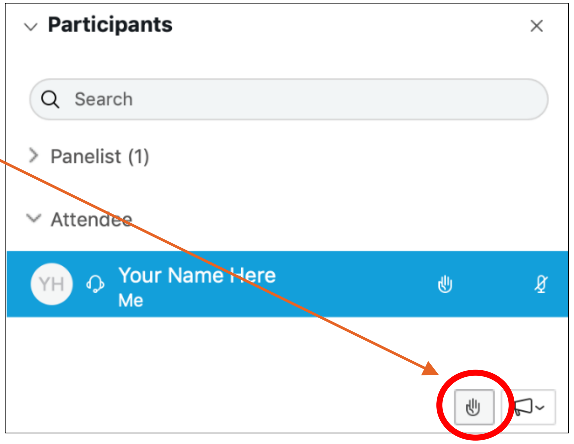
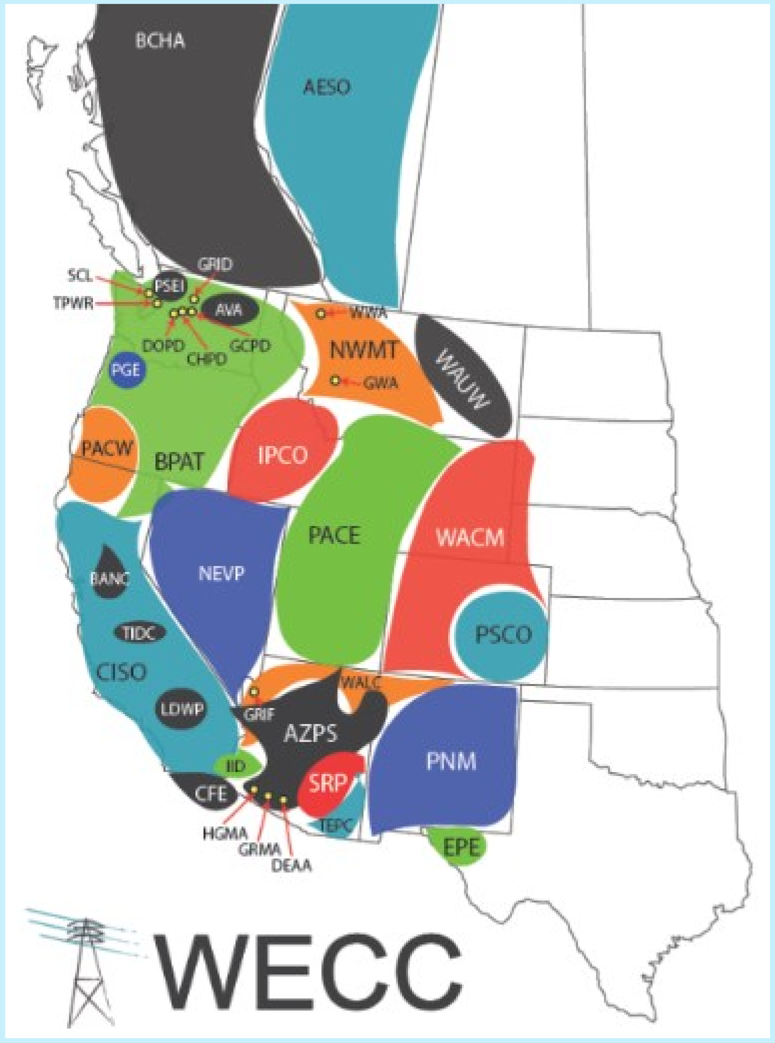


BREAK

CASE STUDY:
CLIMATE RESILIENCE IN IRP ACROSS THE WESTERN U.S.

Climate resilience in IRP across WECC as a use case



What is the range of interpretations of "resilience" in grid planning efforts, looking through the IRP lens?

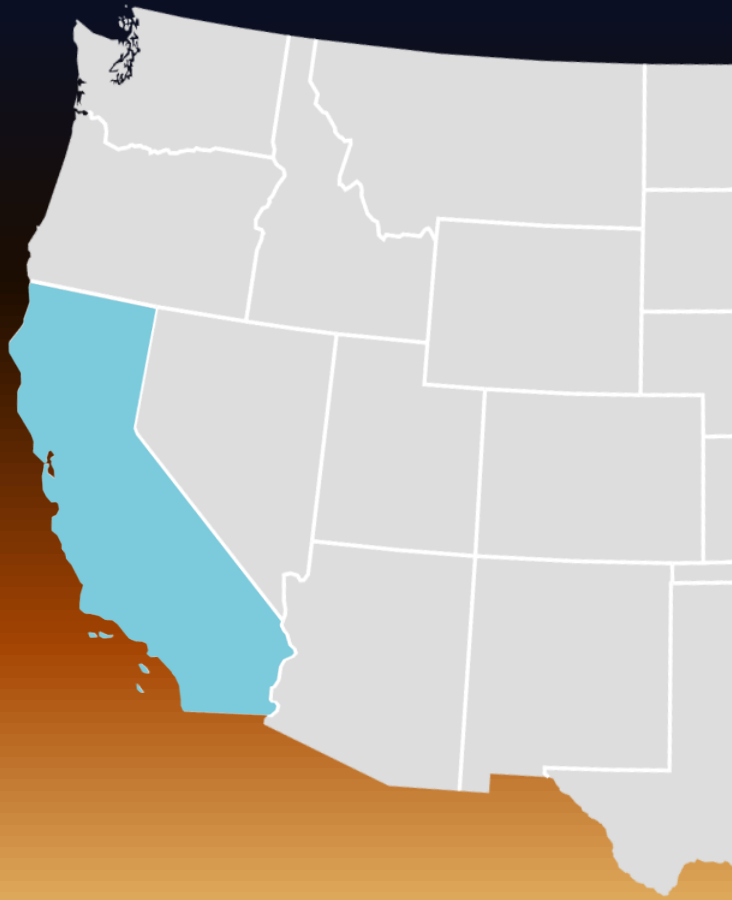
- Reviewed 20 utility IRPs across WECC, accounting for over 75% of system load
  - Of those reviewed 4 IRPs were CPUC-regulated
- While term "resilience" is mentioned in most IRPs, the scope/maturity of how it is discussed in the plans varies significantly
- Climate change and adaptation needs are increasingly recognized in IRPs, but how to best characterize impacts on electric grid for the IRP studies is an area of active research and development

Example: California Load Serving Entities (LSEs)

- Public Utilities Code Section 454.52(a)(1)(G) requires IRPs to:

  "Strengthen the diversity, sustainability, and resilience of the bulk transmission and distribution systems, and local communities."

- In the latest 3 large IOU IRPs reviewed, this is addressed by a diverse resource portfolio that supports grid reliability and emission targets, and in that portfolio, energy storage highlighted as a flexible resource that improves resilience
  - Without a clear and standardized definition of "resilience", the IRP requirement above is subject to a wide range of interpretations, and thus, difficult to address systematically
- Several parallel efforts are ongoing to improve customer and community resilience but not integrated into IRP analyses
- Climate risks are increasingly recognized, but the effects are not (yet) fully included in the LSEs' planning process



Example: LADWP

- 2022 Power Strategic Long-Term Resource Plan (SLTRP) sets core objectives as power reliability, **resiliency**, affordability, and environmental justice/equity
- Reliability and resilience is discussed together throughout the plan, but LADWP makes a clear distinction between the two terms:

  "While grid reliability is centered around having sufficient resources to adequately meet load while accounting for commonly-expected events (e.g. equipment failure, short-duration outages), resilience focuses on high-impact, low-frequency events that are often unexpected and can result in long-duration outages."

- Highlighting there are no widely-adopted or standard definitions/metrics on grid resilience, LADWP uses the following definition:

  "The ability of a power system to anticipate, absorb, adapt, and rapidly recover from a certain set of high-impact, low-frequency events, and to supply sufficient capacity, energy, and services to its customers at all times of the year while managing societal impacts and meeting policy objectives."

  - Study addressed resilience through "sensitivities" on extreme events focusing on major transmission outages like the 2019 event caused by wildfires
  - IRP report also pointed to future approaches to quantify resilience by using value of lost load (VoLL) in cost-benefit analyses or calculating social burden of outages on communities

Example: Avista Corp.

- In Washington, Clean Energy Transition Act (CETA) requires:

  "equitable distribution of energy benefits and reduction of burdens to vulnerable populations and highly impacted communities; long-term and short-term public health, economic, and environmental benefits and the reduction of costs and risks; and energy security and resiliency"

  - The act doesn't define what resiliency is

- 2021 IRP uses reliability and resilience together, and considers resilience as the ability to quickly recover from an outage:

  "The Company views resiliency and reliability as related terms. Measuring resiliency as when an outage occurs and considers how long it takes to return service to customers. If reliability is 100 percent, the system is also resilient as there are no outages to return service from."

  - CAIDI used as a measure of resiliency based on average # of minutes customers are offline during an outage

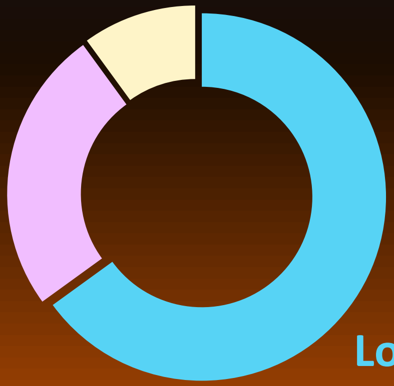
- Ongoing 2023 IRP effort defines energy resilience as ability to adapt to challenging conditions from disruptions
  - Scope discussions on which resilience topics to be evaluated in the IRP vs. other planning forums
  - Customer Benefit Indicators (CBI) developed to address CETA requirements above
  - Resilience captured in two CBI metrics: (1) Energy Availability based on CAIDI, energy storage capacity, planning reserve margin, and (2) Generation Location as % of generation in WA or connected to Avista

Example: Puget Sound Energy

- Also in Washington, under Clean Energy Transition Act (CETA) requirements
  - IRP includes Clean Energy Action Plan (CEAP) under a long-term view
  - Clean Energy Implementation Plan (CEIP) develops specific 4-year targets for solutions proposed in the IRP/CEAP, considering equitable distribution of customer benefits and feasibility of implementation
- As a part of CEAP, PSE pursues energy security and **resiliency** investments such as microgrids or infrastructure hardening at locations that could include highly impacted communities, transportation hubs, emergency shelters and areas at risk for isolation during significant weather events or wildfires
- In 2021 IRP, PSE's customer benefit indicators for portfolio analysis include “Energy Resilience” measured in capacity of distributed storage added
- The plan also considers:

  “System enhancements that will improve resiliency, such as the ability to deliver electricity via a second line, possibly from another substation, to make the grid more self-healing.”

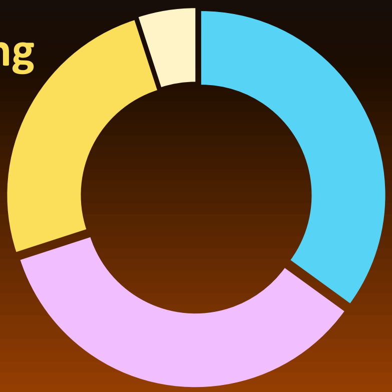
Maturity of resilience definitions in the IRPs



- Almost 2/3 of the IRPs across WECC reviewed either do not mention resilience, or use resilience as buzz word without defining or explaining what it means
- Some fit it into a traditional IRP framework and recognize climate risk via scenario analysis, but often use resilience and reliability interchangeably
- Only a few IRPs define resilience, distinguished from reliability, and working towards developing scope/analytics to incorporate resilience evaluation into their IRP framework

*Of the 20 plans reviewed, 4 IRPs were CPUC-regulated.

Climate change impact considered in the IRPs



Advanced 5%

Climate projections utilized more comprehensively on broad range of system elements

None 35%

Impacts of climate change on electric system not explicitly considered

Emerging 25%

Climate projections utilized for some key model inputs

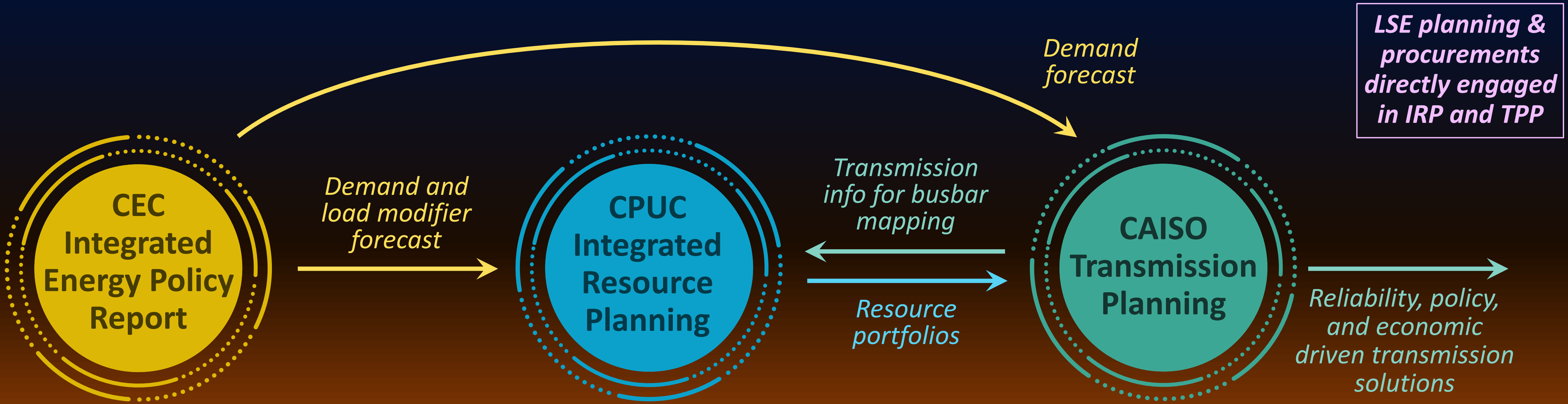
Limited 35%

Climate impacts captured in a limited way (e.g., extrapolate historical trends, run 1-off sensitivities)

- Climate change and adaptation needs are increasingly recognized in IRPs
- How climate change impacts are characterized and modeled under the IRP studies is evolving; current approaches range from extrapolating historical trends and running extreme weather sensitivities, to more systematically incorporating future climate scenarios
- Primary focus has been temperature effects on electric demand, but more entities are starting to explore also changes in supply availability under a broader set of weather events

*Of the 20 plans reviewed, 4 IRPs were CPUC-regulated.

Current IRP/bulk grid planning in California


LSE planning & procurements directly engaged in IRP and TPP

Demand forecast

CEC Integrated Energy Policy Report

Demand and load modifier forecast

CPUC Integrated Resource Planning

Transmission info for busbar mapping

Resource portfolios

CAISO Transmission Planning

Reliability, policy, and economic driven transmission solutions

- ☐ *Climate change impacts not comprehensively included yet (ongoing R&D)*
- ☐ *DERs modeled with static wholesale market responsiveness*

Least-cost portfolio optimization to meet:

- ✓ **System reliability requirements** } Planning reserve margin and need assessment tied to 0.1 LOLE (loss of load expectation of 1 day in 10 years)
- ✓ **GHG reduction target**

Resilience vulnerabilities raise the stakes

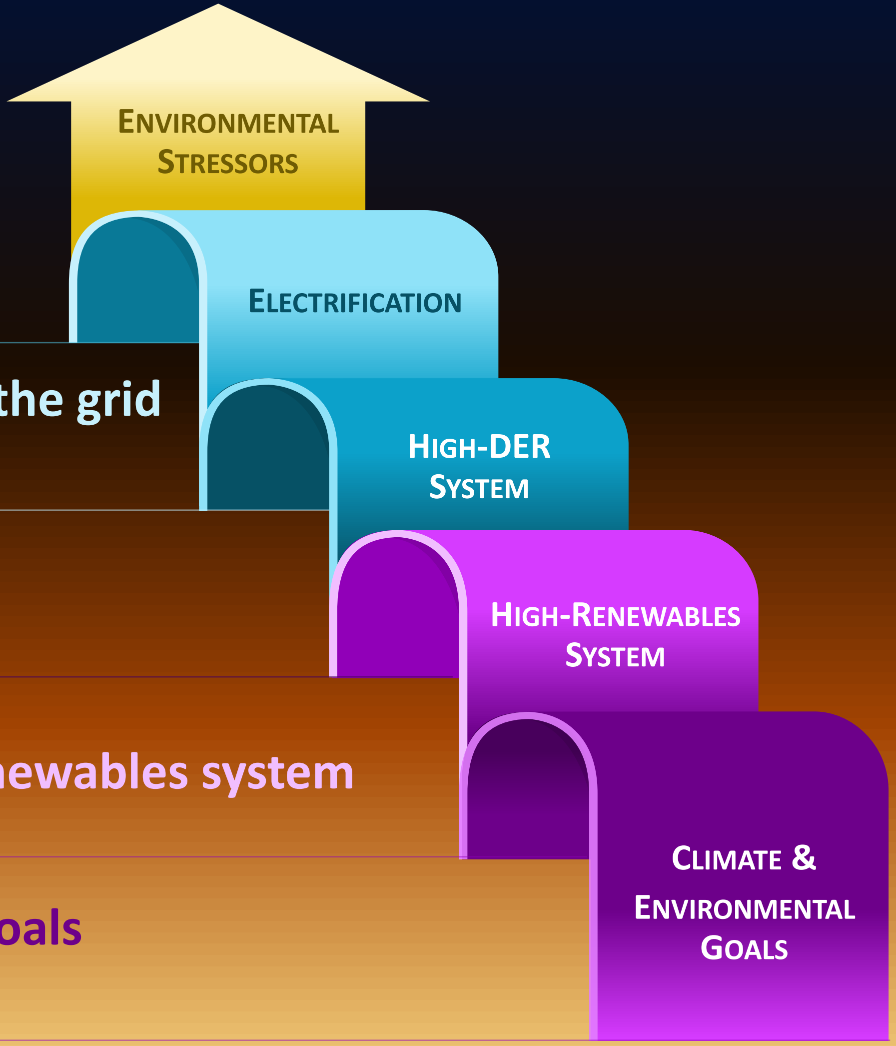
Concurrence & compounding effects of environmental stressors on the grid and directly on customers

Electrification creates new uncertainties & shift vulnerabilities on the grid
e.g., Electric heating during winter events

Institutional barriers to addressing resilience in a high-DER system

Institutional barriers to planning for reliability targets in a high-renewables system

Resilience solutions must also satisfy climate and environmental goals
e.g., Diesel backup generators not a sustainable option



Environmental Stressors

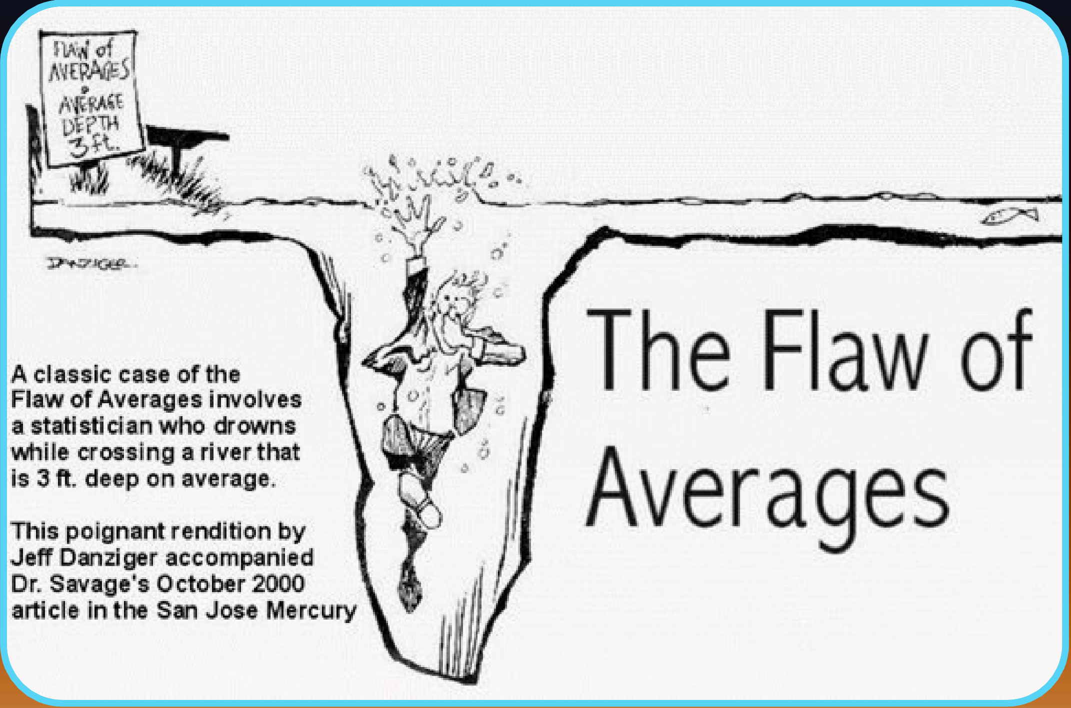
Electrification

High-DER System

High-Renewables System

Climate & Environmental Goals

Geography to hazards and flaw of averages



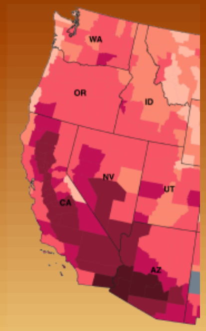
The Flaw of Averages

A classic case of the Flaw of Averages involves a statistician who drowns while crossing a river that is 3 ft. deep on average.

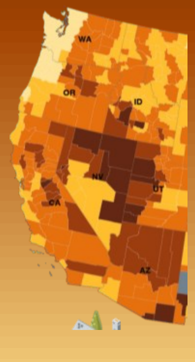
This poignant rendition by Jeff Danziger accompanied Dr. Savage's October 2000 article in the San Jose Mercury

- Hazards and vulnerabilities are locational
- Over-relying on "average" metrics can misrepresent the associated risk profiles
- High resolution (3 km) historical and future weather data are available and already in use in multiple industries

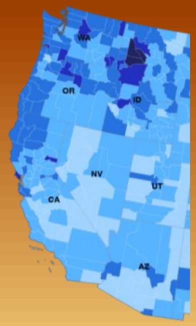
Heat



Fire



Flood



First Street Foundation's Risk Factor™
https://firststreet.org/risk-factor/

Resilience-related gaps in IRP planning

- Need for formal definition of resilience stakeholders agree on and that can be translated into the economic optimization
- Need to identify and model specific resilience vulnerabilities and failure points, geographies, and weather-specific situations
- Need to look at whole grid for solutions, with more planning integration across multiple grid domains
- Need for evaluation of value stacking opportunities, including upstream benefits of resilience investments and synergies to reduce net cost of resilience solutions

Definition

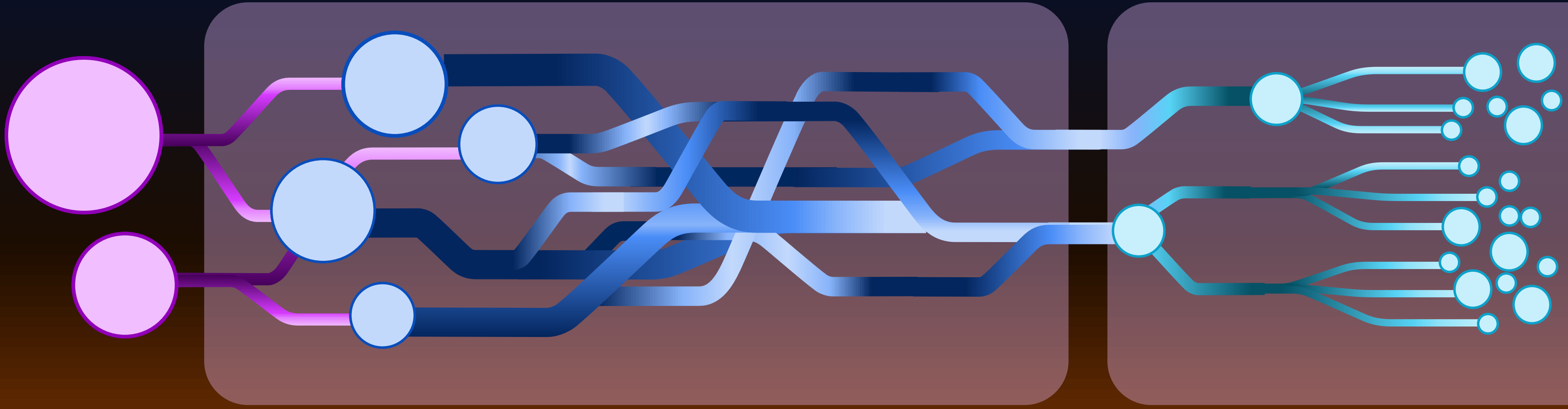
Identification

Integration

Evaluation

*This is for discussion purposes only and is not meant to reflect formal recommendations for the CPUC’s IRP process.

Coordinated grid planning need



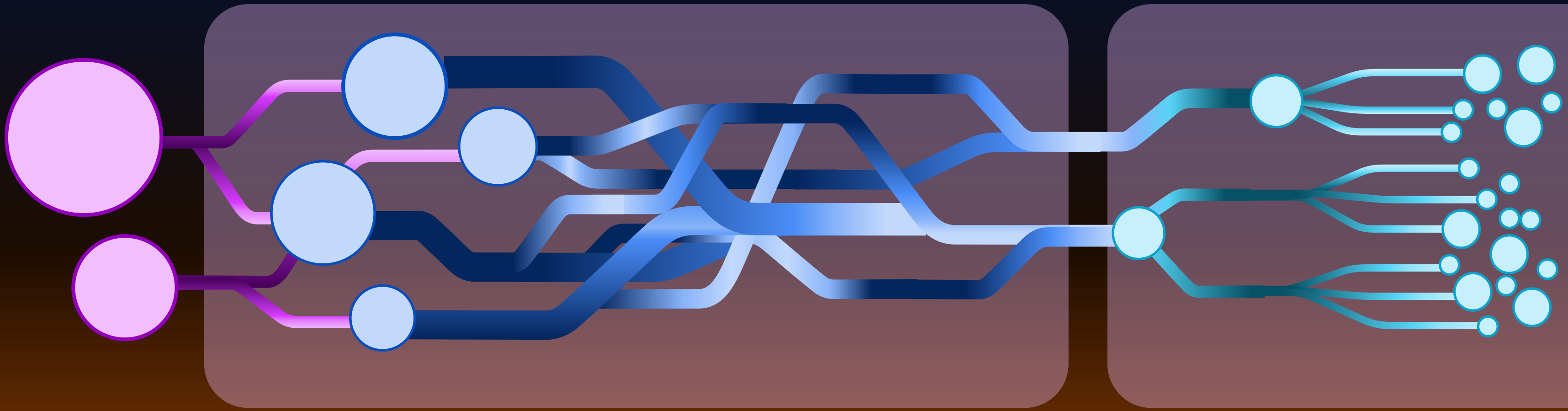
Traditional resilience solutions, such as diesel generators:

- **Provide downstream benefits only**
- **Needed/used rarely only for backup**

Historically:

Bulk grid planning efforts were mostly separated from customer/community resilience needs and solutions

Coordinated grid planning need (cont'd)



Today's resilience solutions include flexible resources like energy storage that can <u>also</u>:

- Provide upstream benefits to bulk grid
- Support clean energy transition

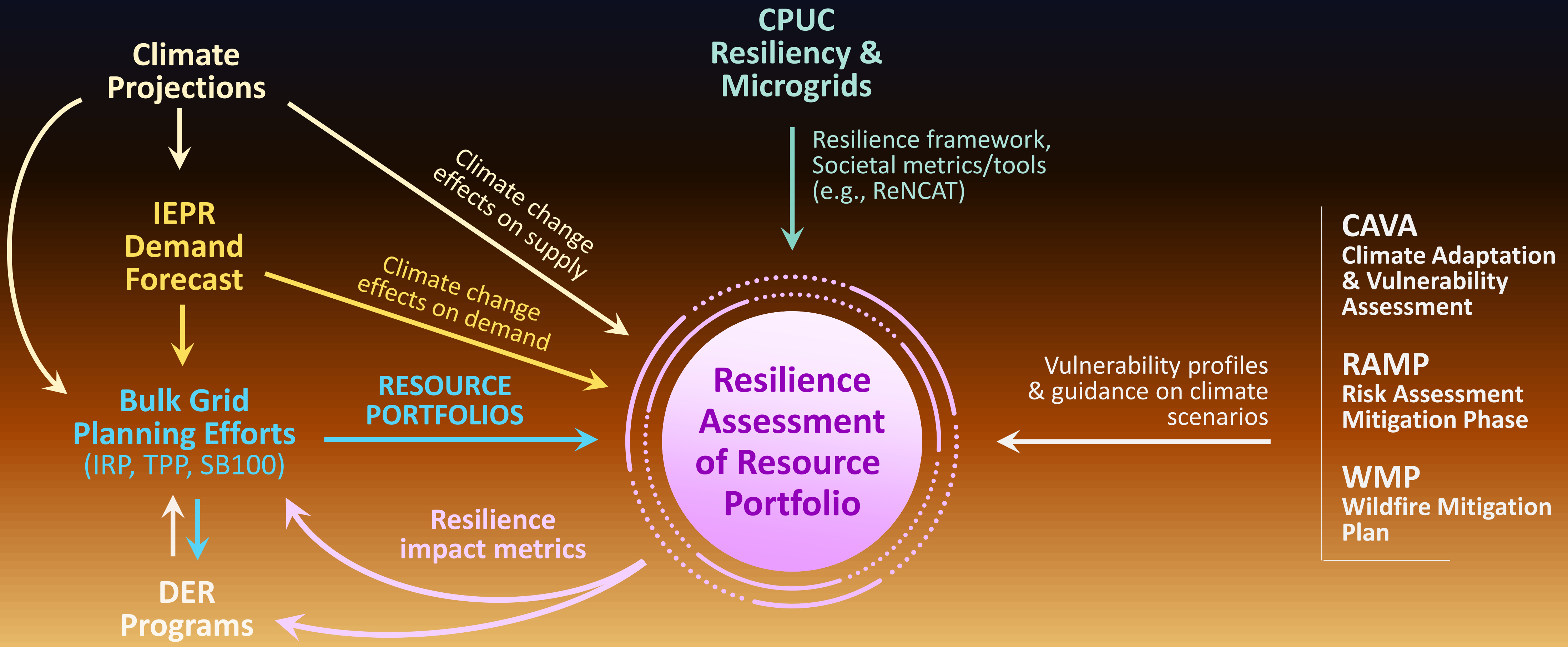
<u>Going forward</u>:

Bulk grid planning needs to consider contributions (and limitations) of DERs that can provide services in multiple grid domains

Value stacking reduces net cost to provide resilience, and can impact economic feasibility and ranking of mitigation measures needed for resilience

How to integrate “resilience” into resource planning?

Climate-resilient resource planning requires a comprehensive resilience assessment tapping into several related but currently disconnected efforts in the state



Climate Projections

IEPR Demand Forecast

Bulk Grid Planning Efforts (IRP, TPP, SB100)

DER Programs

Climate change effects on supply

Climate change effects on demand

RESOURCE PORTFOLIOS

Resilience impact metrics

CPUC Resiliency & Microgrids

Resilience framework, Societal metrics/tools (e.g., ReNCAT)

Resilience Assessment of Resource Portfolio

Vulnerability profiles & guidance on climate scenarios

CAVA
Climate Adaptation & Vulnerability Assessment

RAMP
Risk Assessment Mitigation Phase

WMP
Wildfire Mitigation Plan

Blue sky operations and value

How should we think about “Blue Sky” operations and value in resilience planning?

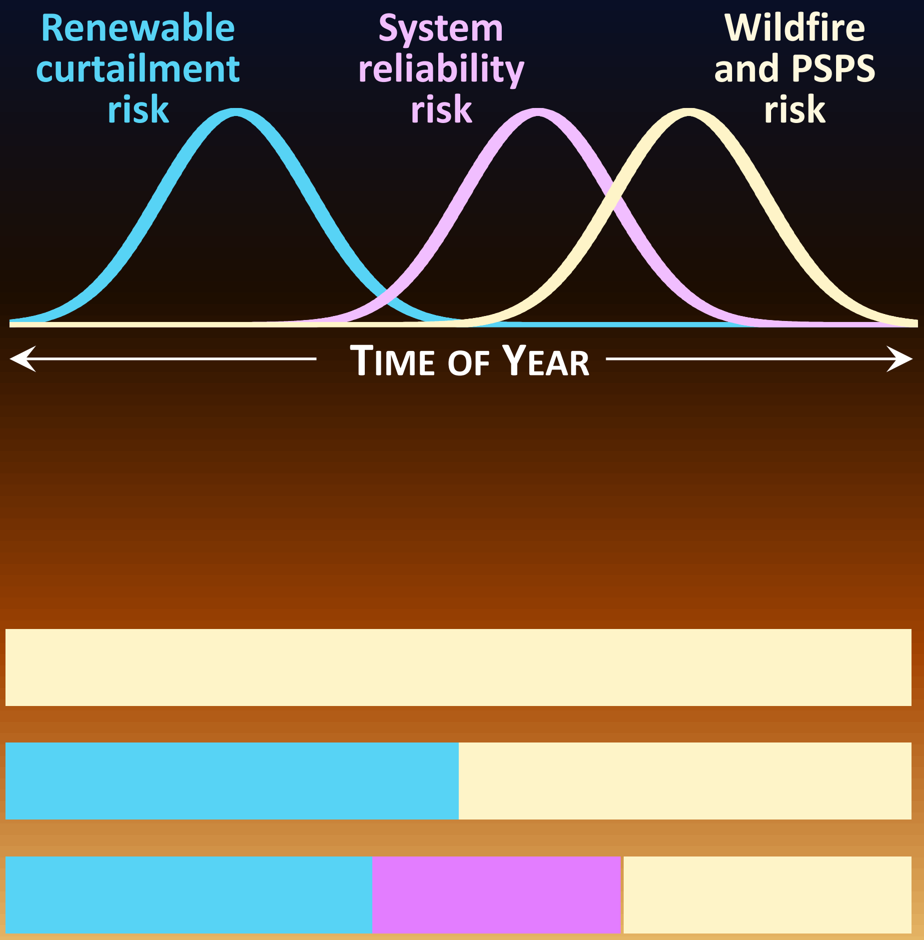
CPUC’s 4 Pillar resilience valuation methodology identifies contributions to grid & state policy goals under Blue Sky conditions as a key factor to consider for a performance-based design

- Blue Sky services can reduce the net resilience costs and improve the economic feasibility of mitigation measures
- … but it can also limit the capacity available during Black Sky events

Alternative approaches:

A. Prioritize resilience above all	Little/no room for Blue Sky services Highest resilience, but also highest net cost
B. Set minimum resilience target and offer Blue Sky services after target is met	Keep control over resilience level Use a portion of capacity towards grid services
C. Evaluate risk profile and dynamically allocate capacity made available for Blue Sky services	Continuous risk assessment/monitoring Maximize value stacking

Value stacking example



- ***Threats and risk profiles are not always coincident***
- ***Flexible resources can adjust their use cases and priorities to enable value stacking***
- ***Residual risk and economic tradeoffs need to be evaluated to determine optimal use and configuration***

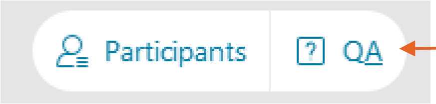
  (E.g., Going from A to B/C leaves residual risk against PSPS events, which needs to be weighed against value gained)

Use Case	Customer Resilience	System Reliability	Renewable Integration
A	✓✓✓	✗	✗
B	✓✓	✗	✓✓✓
C	✓	✓	✓✓

Discussion and Q&A

WebEx Tip

Option 1:



Access the written Q&A panel here

Option 2:

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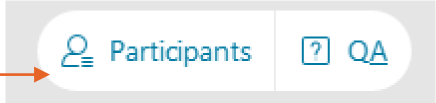

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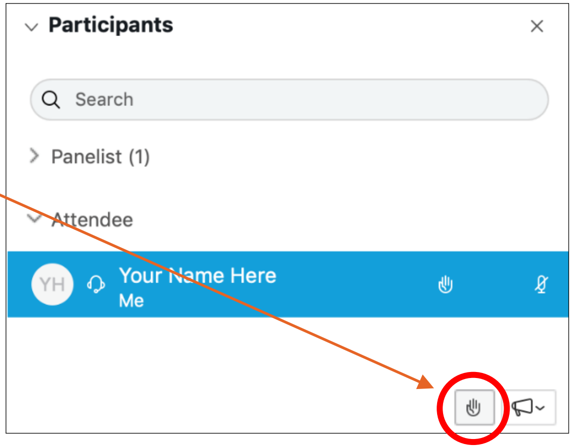

THANK YOU

IF YOU WOULD LIKE TO SUBMIT INFORMAL FEEDBACK TO THE CPUC, PLEASE COMPLETE OUR POST-WORKSHOP SURVEY

JOIN US FOR OUR NEXT WORKSHOP IN EARLY SUMMER 2023!

LEARN MORE ABOUT WARP TO RESILIENCE AND JOIN OUR MAILING LIST FOR STUDY UPDATES
www.lumenenergystrategy.com/resilience

FOR FURTHER READING WE HIGHLY RECOMMEND:

Other workshops and materials in this proceeding, including 4 Pillars Methodology and Staff concept paper:
https://www.cpuc.ca.gov/resiliencyandmicrogrids

Also:

Gorman, Will. 2022. “The quest to quantify the value of lost load: a critical review of the economics of power outages.” *The Electricity Journal.* 35 (2022) 107187. September 1, 2022. https://doi.org/10.1016/j.tej.2022.107187

Jasiūnas, Justinas, et al. 2021. “Energy system resilience—a review.” *Renewable and Sustainable Energy Reviews.*
https://www.sciencedirect.com/science/article/pii/S1364032121007577

Rickerson, Wilson, et al. 2022. *Valuing Resilience for Microgrids: Challenges, Innovative Approaches, and State Needs*.
https://www.naseo.org/data/sites/1/documents/publications/NARUC_Resilience_for_Microgrids_INTERACTIVE_021122.pdf

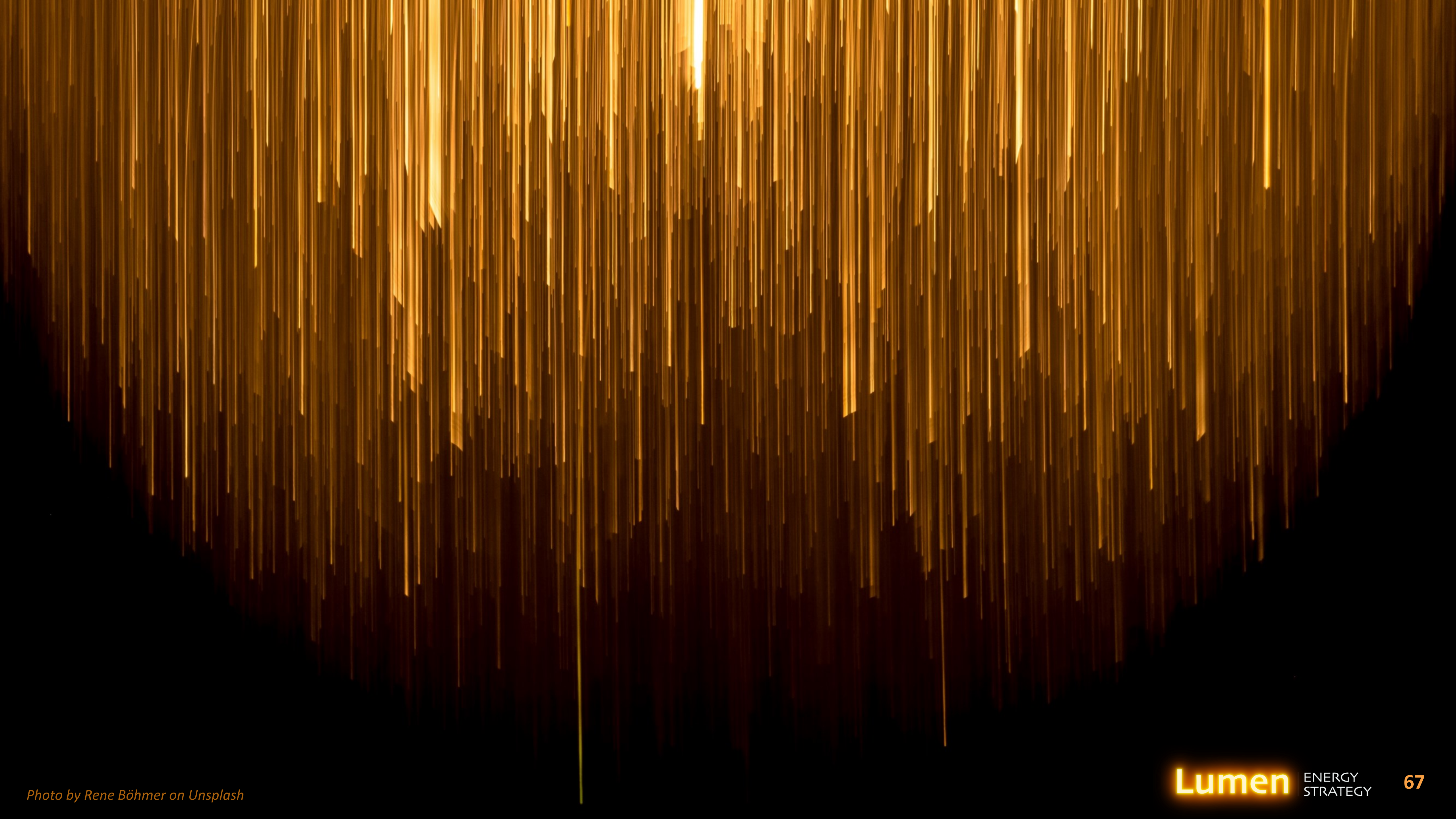

Photo by Rene Böhmer on Unsplash

Closing Remarks, Commissioner Shiroma

For more information:

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Julian Enis
Julian.Enis@cpuc.ca.gov

https://www.cpuc.ca.gov/resiliencyandmicrogrids/

Additional Resources

Resiliency Valuation Methodology – 4 Pillars

I. Baseline Assessment:

1. Define Geographical area of study
2. Define Load Tiers or Consequence Categories (Critical, Priority, Discretionary)
3. Identify Resiliency Targets within Load Tiers
4. Define Hazards to consider (All-Hazard assessment, analysis, ranking, weighting)
5. Conduct assessment of current Resiliency when disrupted from Hazard 1, Hazard 2, Hazard 3 (according to Hazard assessment)
6. Results of Resilience Assessment – Identify Resiliency deficits and priorities and Resiliency Metric Reporting of Baseline levels

II. Mitigation Measure Assessment

1. Identify potential mitigation measure options
2. Assess ability of each mitigation option to reach Resiliency Targets for Hazard 1, Hazard 2, Hazard 3
3. Compare costs of each mitigation option to reach Resiliency Targets for Hazard 1, Hazard 2, Hazard 3

Resiliency Valuation Methodology – 4 Pillars

III. Resiliency "Scorecard"

1. Resiliency Scorecard is a suggested tool that provides a basic benchmark of achievement but recognizes that more can be done.
2. Scoring reflects resiliency configuration characteristics.
3. Scoring system provides for different areas of improvement (e.g. 100% resilience targets are met, but configuration uses 70% fossil fuel resources to meet those targets, improvement would be to decrease fossil fuel resources while maintaining targets. Would result in a higher "score."

IV. Resiliency Response Assessment (computer modeling or post-disruption approach):

1. Conduct Baseline Assessment (1-6).
2. After implementation of chosen mitigation measure option, conduct annual data collection of Resiliency Metrics,
3. Assess achievement of Resiliency Targets and any changes in Community Impacts