Resiliency & Microgrids Working Group
Value of Resiliency – Overview of 4 Pillar Methodology

Resiliency and Microgrids Team, Energy Division

May 5, 2021

California Public
Utilities Commission

WebEx and Call-In Information

Join by Computer:

https://cpuc.webex.com/cpuc/onstage/g.php?MTID=e9ec8b7dcb2ec95bfa3196715984f9323

Event Password: RMWG (case sensitive)

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.

- In this meeting the initial CPUC staff presentation will be recorded, but the ensuing discussion will not be recorded and there will not be meeting minutes.

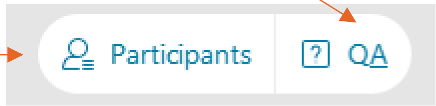
WebEx Logistics

- 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

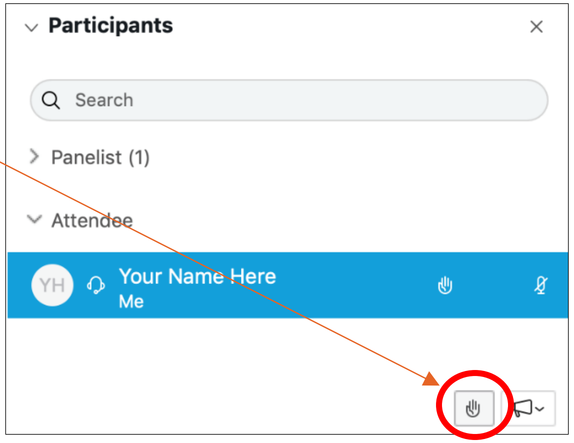
Access the written Q&A panel here

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

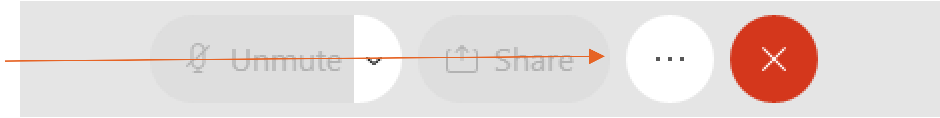


2. Raise your hand by clicking the hand icon.

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.

Register | Go Back

Join Event Now

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First name: Jessica

Last name: Tse

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

Join Now

Join by browser NEW!

Preliminary Resiliency & Microgrids Working Group Schedule

<table>
<tr><th>Month</th><th colspan="4">Resiliency and Microgrids Working Group Topics</th></tr>
<tr><td>February</td><td rowspan="3">Standby Charges</td><td rowspan="4">Multi-Property Microgrid Tariff</td><td></td><td></td></tr>
<tr><td>March</td><td></td><td></td></tr>
<tr><td>April</td><td></td><td></td></tr>
<tr><td>May</td><td></td><td rowspan="4">Value of Resiliency</td><td></td></tr>
<tr><td>June</td><td></td><td></td><td></td></tr>
<tr><td>July</td><td></td><td></td><td></td></tr>
<tr><td>August</td><td></td><td></td><td rowspan="4">Microgrid Interconnection</td></tr>
<tr><td>September</td><td></td><td></td><td></td></tr>
<tr><td>October</td><td></td><td></td><td></td></tr>
<tr><td>November</td><td rowspan="4">Customer-Facing Microgrid Tariff Revisit</td><td></td><td></td></tr>
<tr><td>December</td><td></td><td></td><td></td></tr>
<tr><td>January</td><td></td><td></td><td></td></tr>
<tr><td>February</td><td></td><td></td><td></td></tr>
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Value of Resiliency: Working group participants to discuss resiliency valuation through an all-hazard approach to disruptions and mitigations by examining metrics, methodologies, and policy applications.

Agenda

I. Introduction (CPUC Staff)	2:00 – 2:05
• WebEx logistics, agenda review	
II. Value of Resiliency – Four Pillar methodology	2:05 – 3:15
• Pillar 1 – Baseline Assessment	
• Pillar 2 – Mitigation Measures	
• Pillar 3 – Resiliency Scorecard	
• Pillar 4 – Resiliency Assessment (post-disruption)	
III. Q & A and Discussion	3:15 – 3:55
• Open Discussion	
IV. Closing Remarks, Adjourn	3:55 – 4:00
• Open Discussion	

Value of Resiliency – Overview of a 4 Pillar Methodology

May 5, 2021

Rosanne Ratkiewich

Julian Enis

Resiliency and Microgrid Team

Building Resilient Infrastructure – The Global & Local Goal

United Nations | Department of Economic and Social Affairs
Sustainable Development

SUSTAINABLE DEVELOPMENT GOALS

7 AFFORDABLE AND CLEAN ENERGY

ENSURE ACCESS TO AFFORDABLE, RELIABLE, SUSTAINABLE AND MODERN ENERGY FOR ALL

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

BUILD RESILIENT INFRASTRUCTURE, PROMOTE INCLUSIVE AND SUSTAINABLE INDUSTRIALIZATION AND FOSTER INNOVATION

11 SUSTAINABLE CITIES AND COMMUNITIES

MAKE CITIES AND HUMAN SETTLEMENTS INCLUSIVE, SAFE, RESILIENT AND SUSTAINABLE

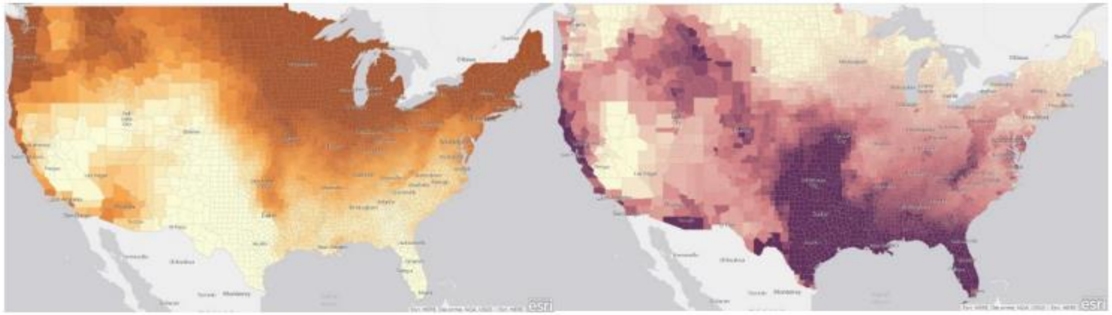
The Problem to Solve: How can we optimize grid investments to maximize resiliency?

- CLIMATE CHANGE DISRUPTIONS: We are expecting **more extreme disruptions** and a **wider range of types of disruptions**. Climate change is turning Low Frequency/High Impact events into **High Frequency/High Impact events.**
- EQUITY DISPARITY: Equity disparity is revealing itself with each event; **resiliency valuation is different for those at opposite ends of the equity and wealth spectrum**.
- INTERDEPENDENCIES: Disruptions highlight **interdependencies between critical infrastructure systems**.
- DECARBONIZATION/ELECTRIFICATION: To minimize climate change, it is **critical to shift to decarbonized electrification**. As this increases dependency on electrical system, it is also critical that measures are taken to **increase confidence in electrification**.

427 Four Twenty Seven Climate Solutions

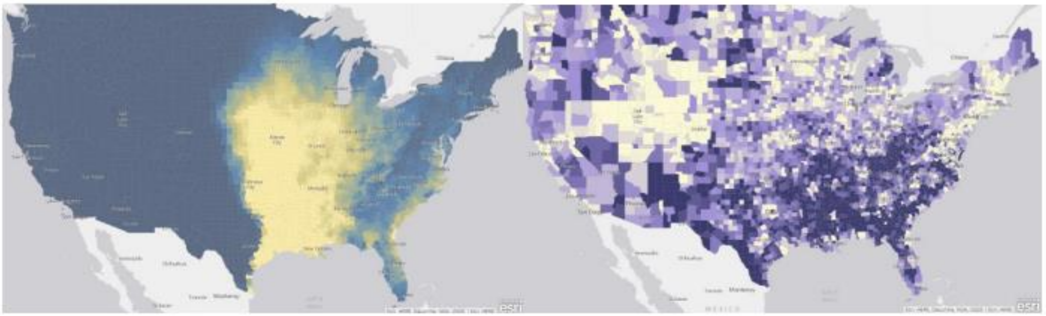
March, 2017

Appendix:



Map 2. Change in the severity of very hot days
Average change in the max wet-bulb temperature between 1981-2005 and 2045-2049

Map 3. Change in the frequency of very hot days
Average number of days over the historical 95th percentile in 2045-2049)



Map 4. Average number of days that exceed HHSI category II days in 2045-2049

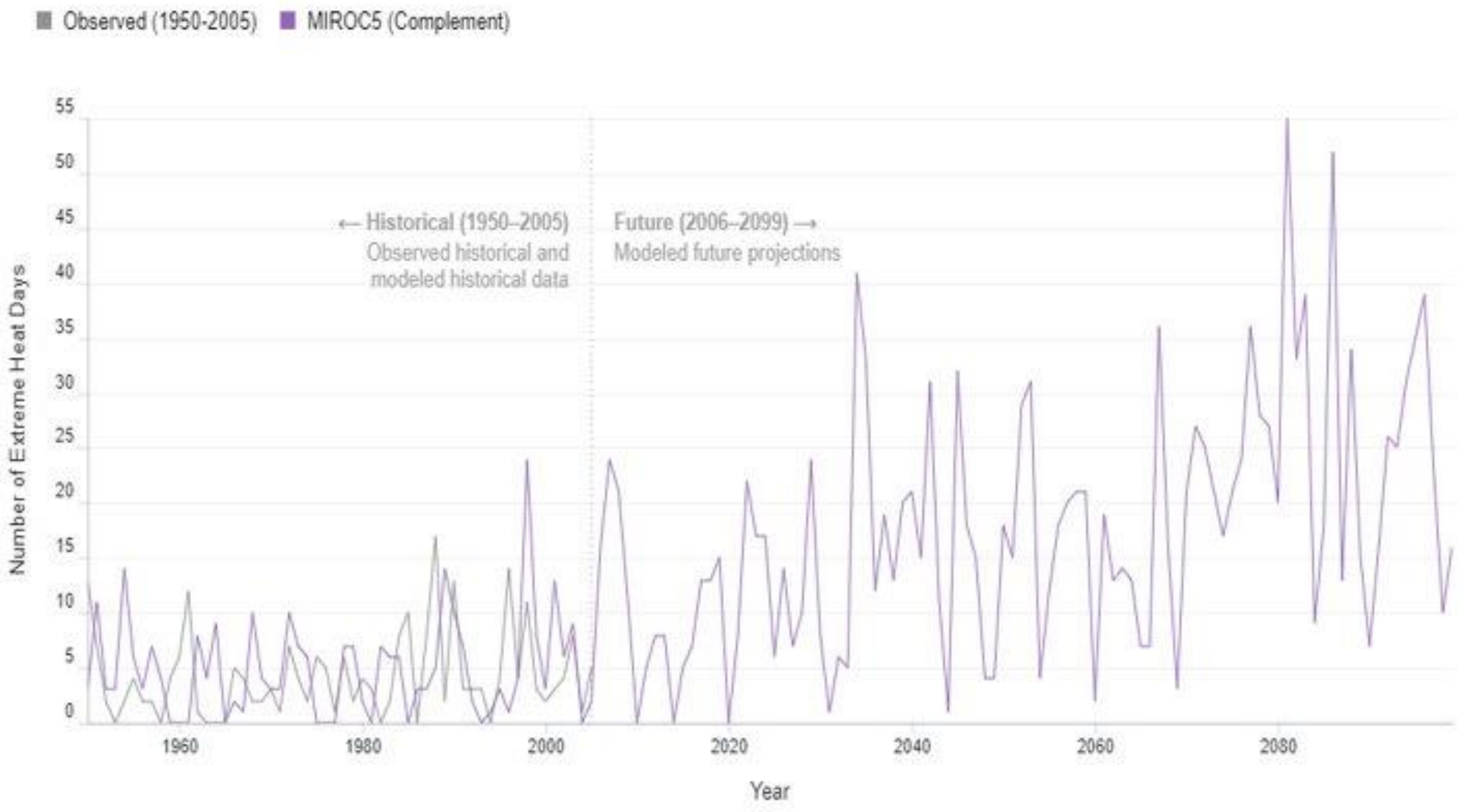
Map 5. Social Vulnerability Score (2016)

Climate Change Event Modeling

The number of **Extreme Heat Days** by Year is projected to continually increase substantially. This graph (chosen to reflect data for **San Joaquin County**) reflects historical data and the MIROC5 data which is the combined data from the hottest/driest and coldest/wettest models.

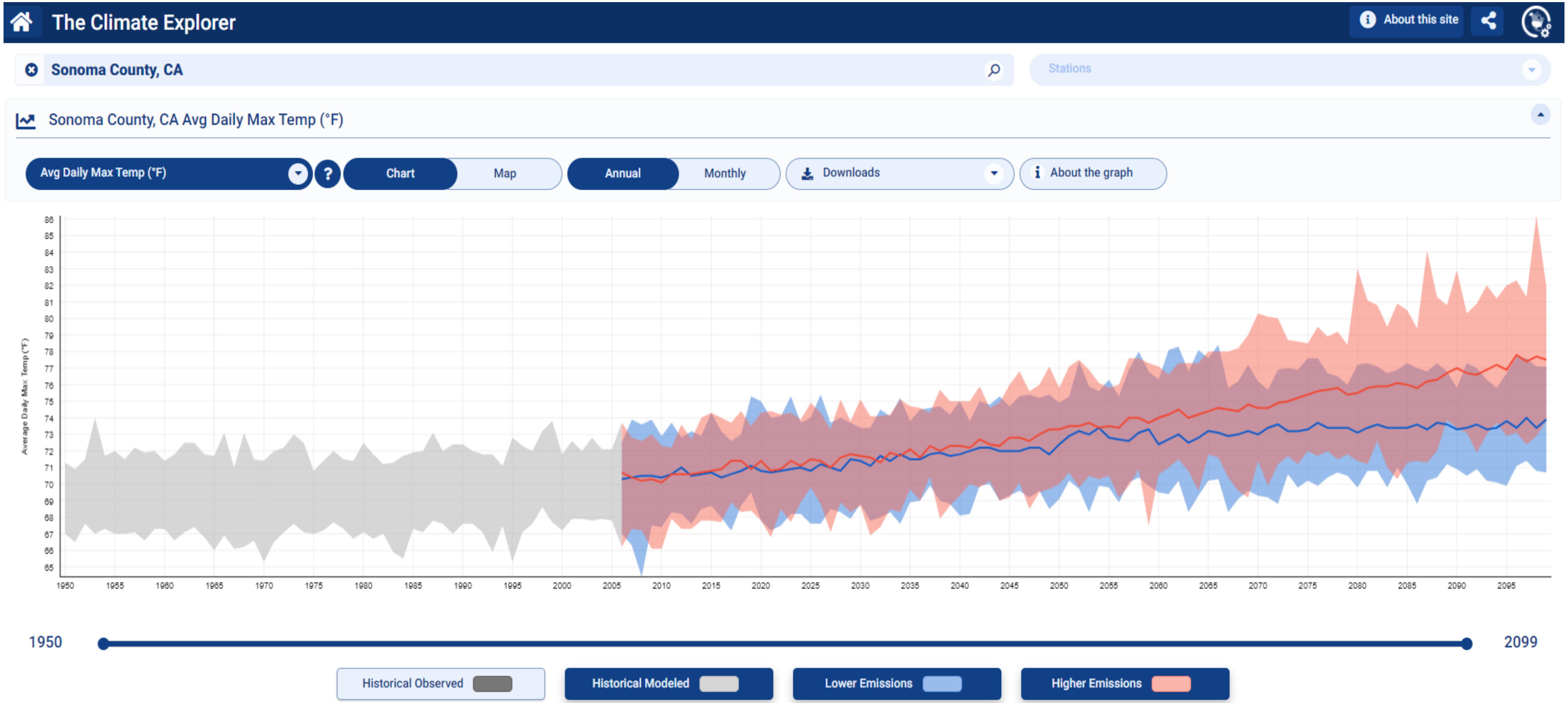
Number of Extreme Heat Days by Year

This chart shows number of days in a year when daily maximum temperature is above the extreme heat threshold of 103.9 °F. Data is shown for Grid Cell (38.58, -121.46) under the RCP 4.5 scenario in which emissions peak around 2040, then decline.



- Source: Cal-Adapt. Data: LOCA Downscaled CMIP5 Projections (Scripps Institution of Oceanography), Gridded Observed Meteorological Data (University of Colorado, Boulder).

Climate Change Event Modeling



The Problem to Solve: How can we optimize grid investments to maximize resiliency?

- **How do we integrate resiliency into regulation** to ensure an **appropriate amount of resiliency investments** are being made in the **right places** that will **benefit our most vulnerable** and that resiliency level is being paid for **without causing undue burden on our most vulnerable?**

- We can't know the answer to this question without **quantifying** through **measuring**, **assessing** and **valuing resiliency**, so we know where best to put enough money and effort to optimize resiliency efforts.

- Difference between Quantifying and Valuing resiliency:

  - ❖ **Quantifying** is to put numbers to the amount of risk reduction a given measure (or bundle of measures) achieves and the cost of that risk reduction, i.e. projects, events, and outcomes.
  - ❖ **Valuing** is to understand these numbers in terms of human impact – how much is the risk reduction worth relative to other solutions

Why Resiliency Valuation is Important

"Under the general theory of welfare economics, the economic value of service reliability is equal to the economic losses that customers experience as a result of service interruptions."

SCE GRC 2021 - (pdf pg. 141 Workpapers
Grid Modernization, Grid Technology, Energy Storage SCE-02 Volume 04, Part 01, Chapter II, Book A

Reliability measures impacts to the system;
Resilience measures impacts to humans.

SANDIA REPORT
Printed February 2017
Resilience Metrics for the Electric Power System: A Performance-Based Approach

$ spent upfront may save significant $ later in losses

Resiliency – Current Metric Methodologies

- *Interruption Cost Estimator* – LBNL: Calculations are based on historical events, no forecasting ability; based on **customer willingness to pay survey of 2012**
- *Value of Lost Load* – RAMP process, e.g. SCE: Value Of Service estimates are based on customer class surveys conducted between December 2018 and June 2019 – so **reflects only PSPS "season" from 2018**.
- *"Resilience Metrics for the Electric Power System: A Performance-Based Approach"*, Sandia National Laboratories: Includes **metric analysis, characterizations of hazards, use cases and heat map of hazards.**
- *Grid Modernization Laboratory Consortium* (GMLC), DOE: Developed metrics and framework for evaluating **power system resilience** as a part of its Foundational Metrics Analysis project.
- *"Resilience Framework Methods and Metrics for the Electricity Sector"*, IEEE – Approach **identifies individual parameters/events** and associated **system-dependent metrics**, then applies pre-defined priority weights/factors, and **an all-hazards framework** toward assessing and developing a program with five main focus areas: **Prevention, Protection, Mitigation, Response, and Recovery** to facilitate the investment decision process.

Electric System Reliability Metrics

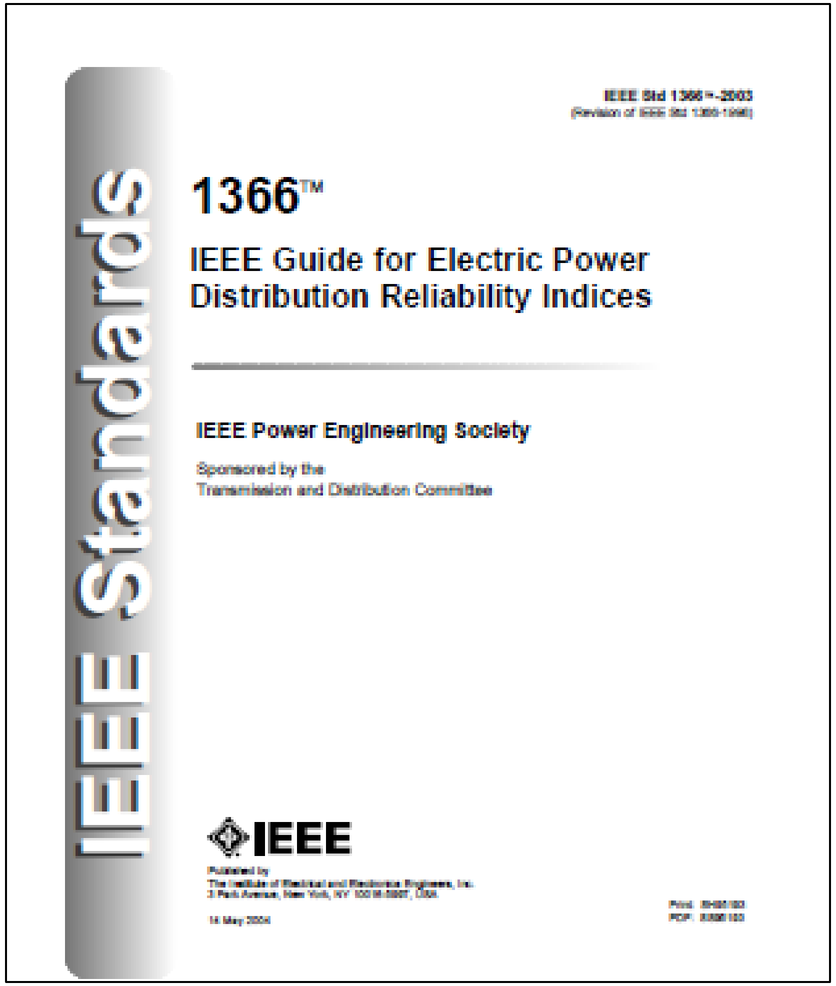
IEEE 1366 defines the four main metrics by which electric system reliability is measured: SAIDI, SAIFI, CAIDI, and MAIFI. These are the generally accepted standards by which electric utilities across the US measure and report system reliability.

SAIDI = System Average Interruption Duration Index

SAIFI = System Average Interruption Frequency Index

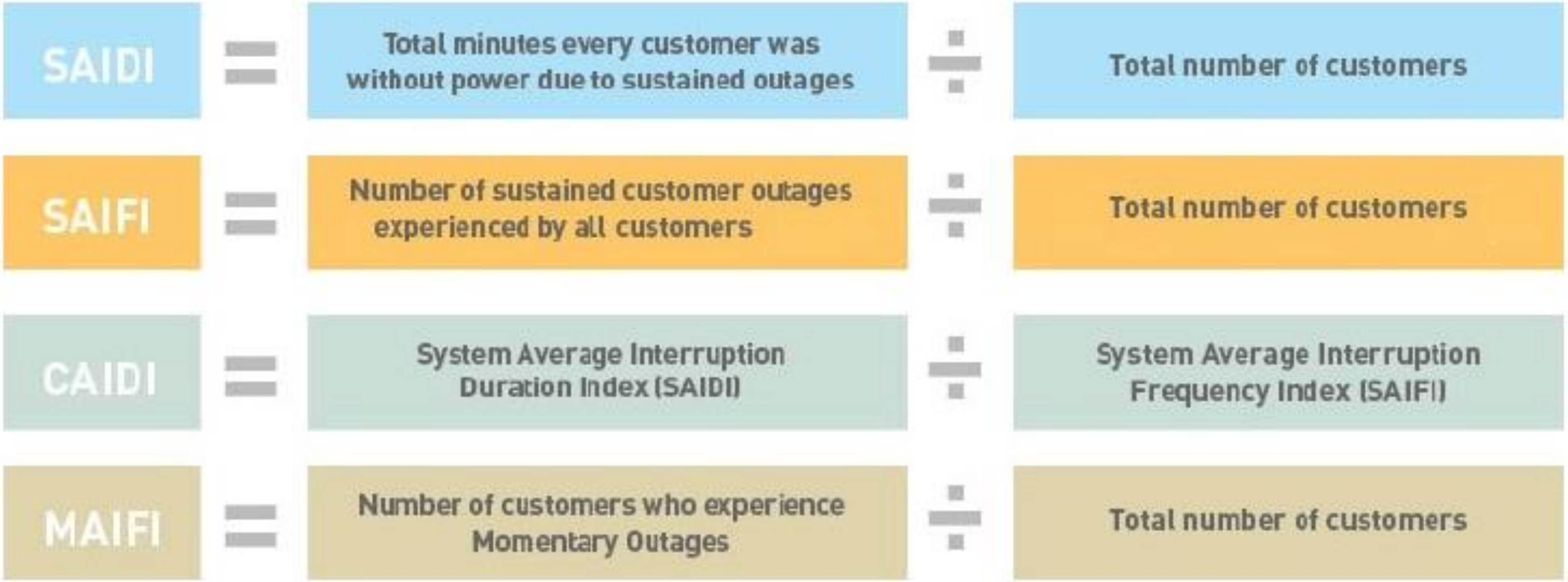
CAIDI = Customer Average Interruption Duration Index

MAIFI = Momentary Average Interruption Frequency Index



Electric System Reliability Metrics

Written definitions of SAIDI, SAIFI, CAIDI, and MAIFI are presented below.



Note: Appendix A contains more detailed mathematical definitions and visual explanations of these four metrics.

Reliability Indices With and Without Major Event Days

- Reliability indices are reported with and without **Major Event Days (MEDs)**.
  - MEDs are defined as days with a daily SAIDI that exceeds a statistical threshold based on the previous 5 years of data.
  - MEDs are high-impact, low frequency events.
  - The definition of an MED does not account for causality.
  - Earthquakes, storms, and Public Safety Power Shutoff (PSPS) events are considered MEDs only insofar as the event's daily SAIDI exceeds T_{MED}.

- Reliability indices are used to ***motivate investment decisions*** that will lead to improvements in reliability.
  - Looking at **reliability without MEDs** -- utility focuses on how it needs to "improve" reliability overall, excluding MED.
  - Looking at **reliability with MEDs** – utility can see how significant events (that might be random in occurrence) can dramatically impact customer experience.

SAIDI = System Average Interruption Duration Index

Drawbacks of Statistical Representation of Data

- The massive size of the utility system– with its regional, climate, and density variations can make system level reliability indices data challenging to interpret.
- Reliability statistics focus on outage duration and customer counts, which may obscure regional variation. See the figure below for an illustrative example of this variation:

	PG&E 2019 SAIDI	PG&E 2018 SAIDI	2019 National Average SAIDI	San Francisco Division SAIDI	Humboldt Division SAIDI
Without MED (minutes)	117.7	99.9	133.3	56.8	274.6
With MED (Minutes)	1365.1	282.9	263.8	71.6	6899.9

Reliability Reporting Requirements and Potential Enhancements

- Current reliability reporting requirements:
  - Six California utilities are required to report annually on their system reliability.
  - The annual reporting template and specifies comprehensive reporting requirements, including division level and historical performance.
  - The Decision also requires the utilities to hold an annual workshop on electric system reliability and make circuit level reliability data available upon request to the public.
  - D.16-01-008 is the governing decision, which includes the reporting template.
- Future improvements we would like to see:
  - GIS formats of data complete with historical metrics.
  - Enhanced data granularity (circuit level).
  - Reliability effects of PSPS and other outage types.
  - Narrative description of mitigation measures taken to remediate poor circuit performance.

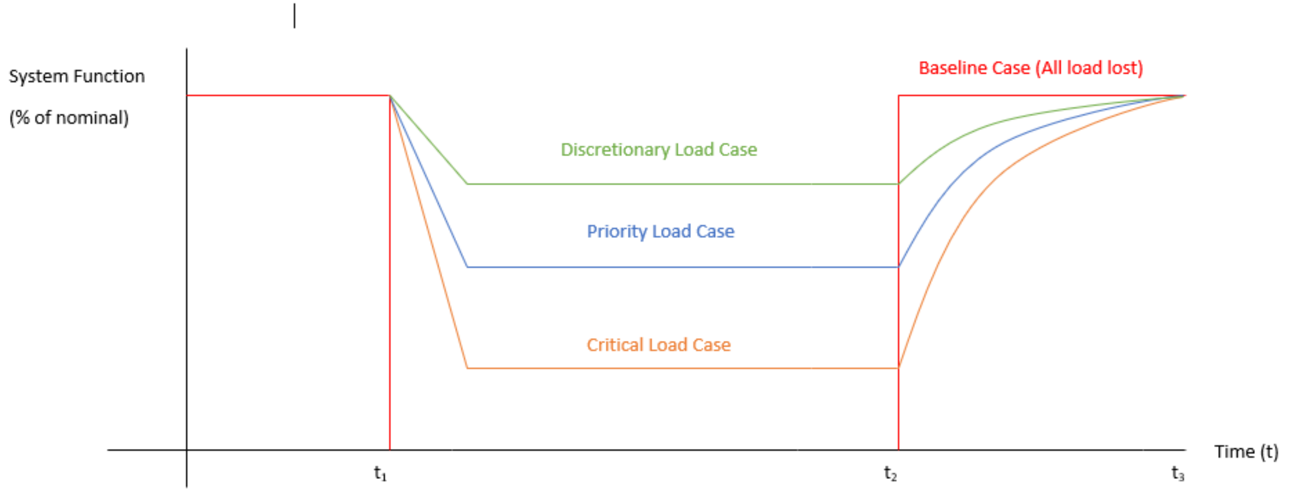
Resiliency and Reliability Overlap

- Describing system resiliency solely using reliability metrics is problematic for the following reasons:
  - Reliability is generally thought of as a measure of and perspective on overall system performance (i.e., the averages reflect what the overall system experiences).
  - Reliability metrics used for system planning purposes often intentionally exclude Major Event Days (MEDs) to avoid the utilities "chasing" low probability events (that are likely random in nature) with expensive upgrades. This excludes the types of large-scale disruptive events that resiliency investments are focused on mitigating.
- However, important insights about the duration and frequency of high-impact, low-frequency disruptive events can be gleaned from the current metrics:
  - CAIDI **including** MEDs and all other outage types can tell us the average duration of an outage for a customer over all recorded outages each year.
  - CAIFI **including** MEDs and all other outage types can tell us the average frequency of outages for a customer over all recorded outages each year.

Resiliency Reflected Within Reliability Indices

- Use of CAIDI and CAIFI **including** MEDs and all other outage types reflects annual system-wide average historical duration and frequency of outage experienced by the electric ratepayer. This can serve as a baseline for assessing mitigation measures through reduction of lost load.
- **Mitigation measures** within a geographically defined area might affect the power outage in such a way as to be represented by a more **gradual decline of lost load** that levels out at an adaptation and duration level **representing an improvement from the baseline case.**
- Reliability Indices data adjustments are needed
  - We would need CAIDI/CAIFI metrics on a more geographically precise level (circuit level) to reflect **location-based experiences** and ensure that **local variation in electric system performance is captured.**
- Questions to answer about this approach:
  - How granular do we need the CAIDI data to make this useful?
    - ❑ Substation level? Circuit level?
    - ❑ What is feasible to have IOUs provide?
  - Use this for an individual event vs. whole year?
    - ❑ Do SAIFI and CAIFI converge for small sample sizes?
    - ❑ Can they be interchanged and what is the cutoff?
  - CAIDI worst case scenario vs. average (all w/ MED); which captures what we're trying to do better?

$$\textit{Customer Lost Load Reduction (kWh)} = \int_{t_1}^{t_2} \textit{Baseline Case} * dt - \int_{t_1}^{t_3} \textit{Build Out Load Case} * dt$$



System Function Relationships to Measure Improved Resiliency

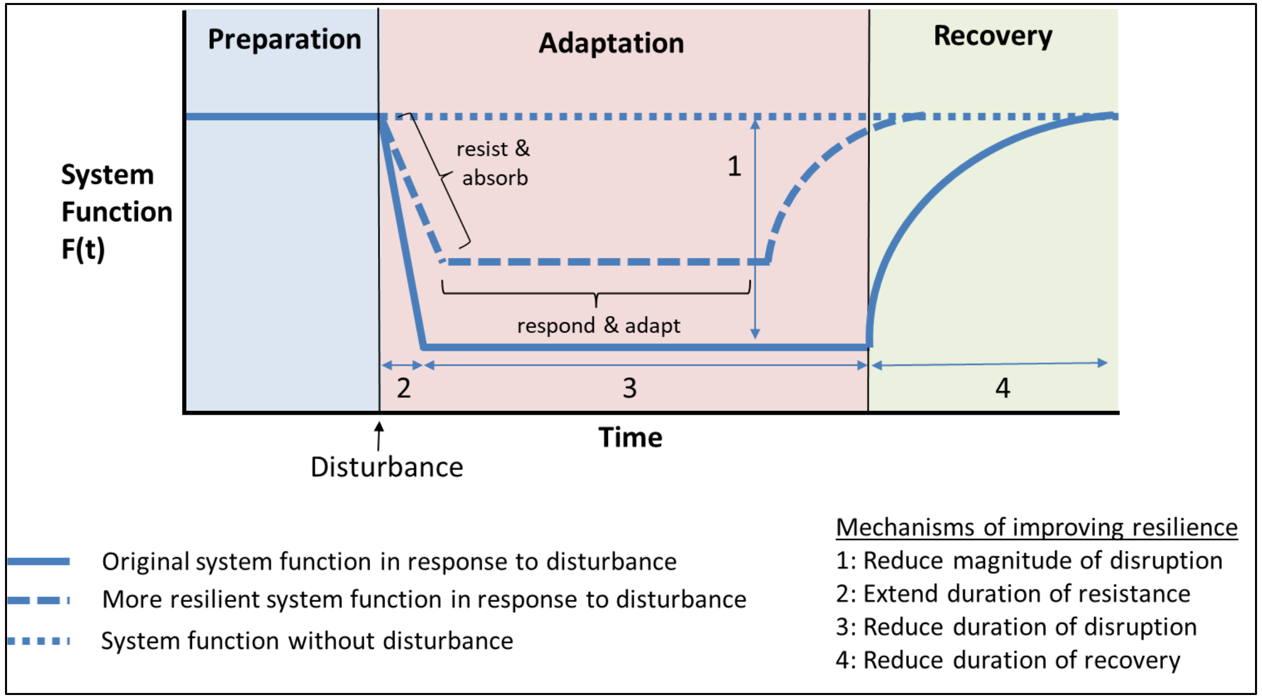
ENERGY System Function:
- **operating** levels – MW, MW/hrs, MW * hours
- **infrastructure** levels -- # lines/circuits functional, # lines/circuits tripped, # lines/circuits restored

INTERDEPENDENT System Functions:
- Water/Wastewater
- Gas
- Communications
- Transportation

ECONOMIC System Function:
- Revenue and productivity due to power disruption
- Income and perishable losses due to power disruption

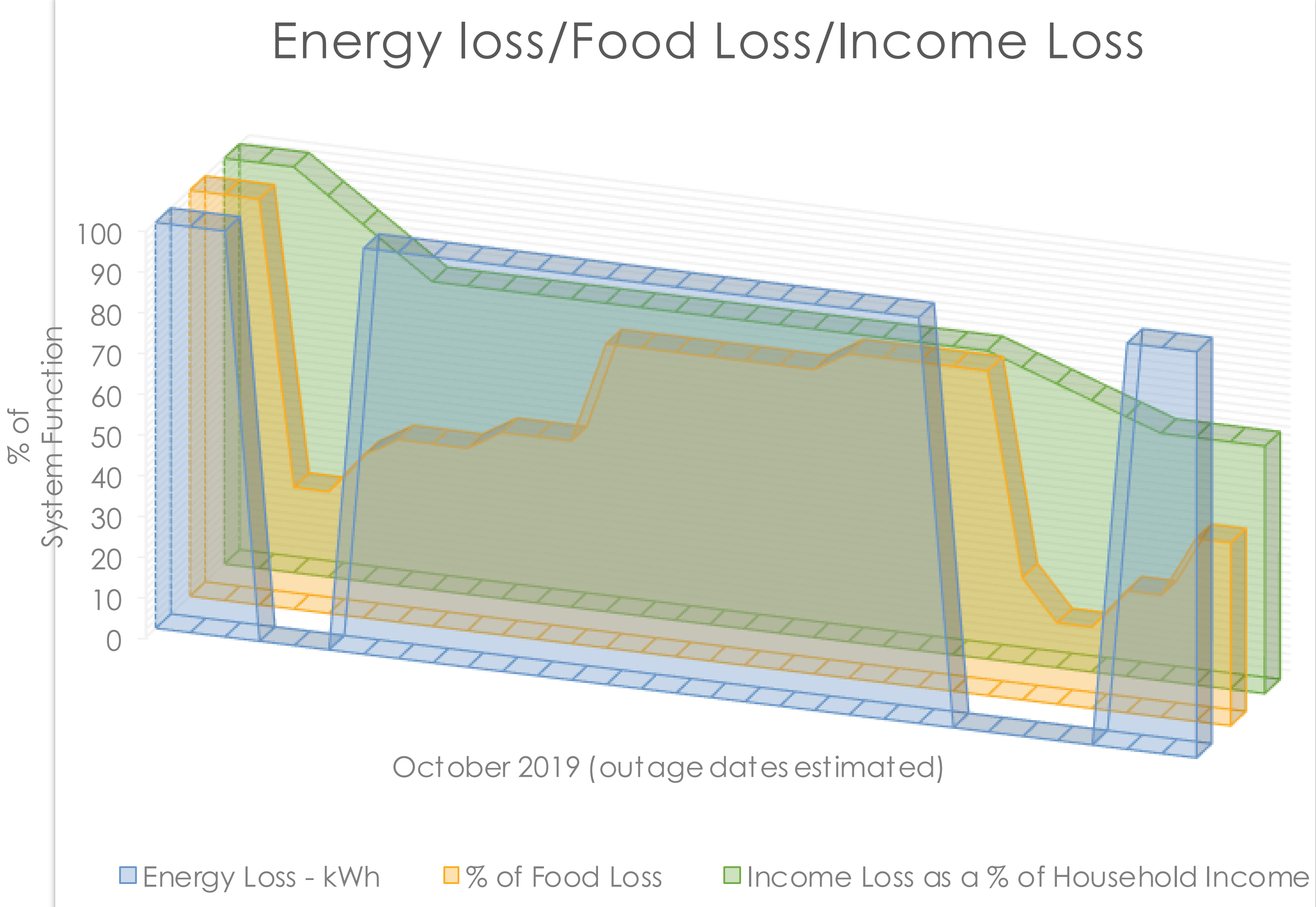
SOCIAL/EQUITY System Function:
- # of vulnerable or disadvantaged population in area served
- # of Critical Facilities

ENVIRONMENTAL System function:
- GHG, Criteria Air Pollutant Emissions



Resilience Trapezoid (adapted from Panteli, et al. (2017); T. Ding, Y. Lin, G. Li, et al. (2017); T. Ding, Y. Lin, Z. Bie, et al. (2017))

Resiliency Measures to Reflect Accumulated Impacts



Case study:

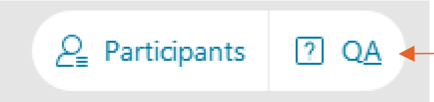
- PG&E turned off power to Ana Patricia Rios' neighborhood in Sonoma County for eight days in October -- **three at the beginning of the month and five near the end**.
- She threw out at least **$500** worth of meat, fruit, vegetables, salsas and other food that would have supplied her family with months of meals.
- Similar losses occurred throughout Rios' wooded, hilly neighborhood, which is mostly home to Hispanic families. Many are **vineyard and hospitality workers, and sometimes several families share a house.**
- Rios family brings in about **$3,500 each month --** $1,000 above the federal poverty level for a family of five.
- Rios **missed eight days of work due to the outages.**
- Her husband **lost four days of work** because of the smoke from the Kincade Fire 40 miles north
- Rios family has **relied heavily on food bank distributions to feed the family since**.

Jackie Botts, CalMatters, https://www.davisenterprise.com/news/local/state-government/we-need-the-food-that-we-lost/

Discussion and Q&A

WebEx Tip

Option 1:



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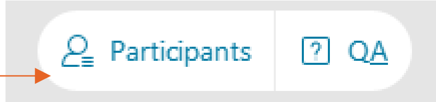

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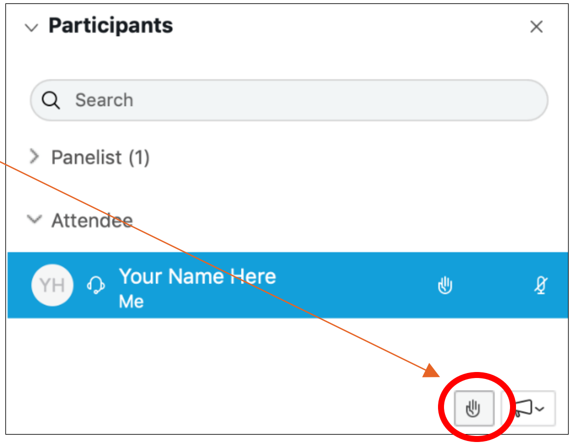
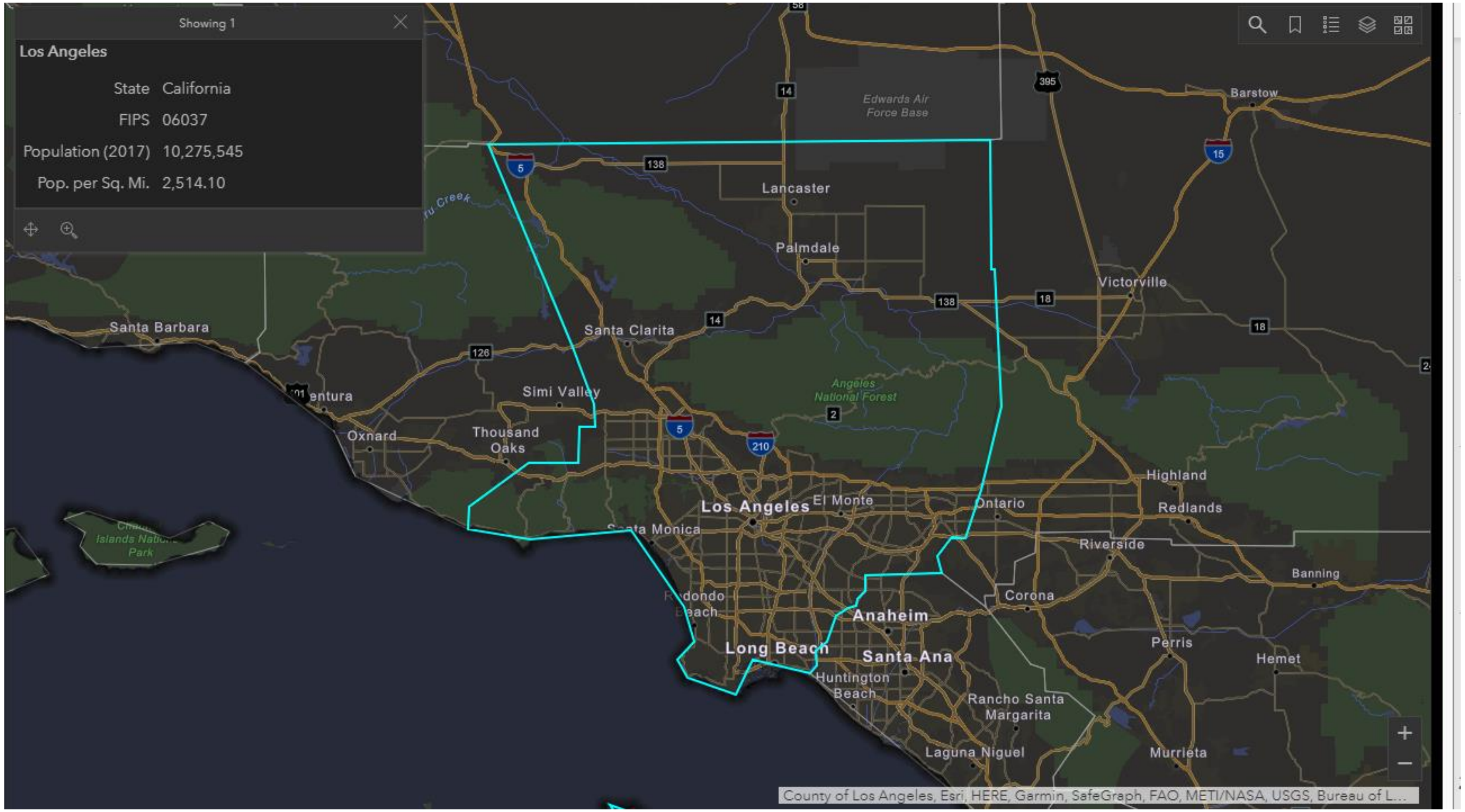


The Problem to Solve: How can we optimize grid investments to maximize resiliency?



The Problem to Solve: How can we optimize grid investments to maximize resiliency?

4 Pillars of Resiliency Valuation

I. **Baseline Assessment**
   I. What do we want to protect and where is it?
   II. What threatens it?
   III. How well are we doing now to protect it?

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

III. **Resiliency Scorecard** – scoring resiliency configuration characteristics

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

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

Resiliency Valuation Methodology

4 Pillars of Resiliency Valuation – The Details

I. Baseline Assessment
II. Mitigation Measure Assessment
III. Resiliency Scorecard
IV. Resiliency Response Assessment (post-disruption)

Resiliency Valuation Methodology
I. Baseline Assessment

Based on:
- Electrical infrastructure
- City or County Lines
- Project scope
- Local/Tribal Gov't Hazard Mitigation plans

Identify:
- Resource availability/ limitations such as land available, zoning, current generation and/or storage
- Commercial and industrial economy
- Wealth disparities
- Population demographics and needs

Map:
- Critical Facilities, Critical Infrastructure, Essential service assets, C & I, retail, residential

1. Define Geographical Area of Study

2. Define Load Tier Assets: Critical, Priority, Discretionary

Load Tier assets example:
- Critical:
  Critical Facilities, Critical Infrastructure, Medical Baseline, Emergency 1st Responder systems, DAC, VC, Food Banks, Evacuation Centers
- Priority
  Essential services such as gas stations, charging stations, banks, food supply chain: grocery stores, food distribution centers, agricultural centers
- Discretionary
  Commercial/Industrial, Retail stores, residential neighborhoods, recreational centers

- Who defines what is in these Load Tier assets? Collaboration between:
  - ❖ Local Government/Tribes
  - ❖ IOUs
  - ❖ Developers

3. Identify Resiliency Targets in Load Tiers

- Resilience duration required
- Maximum duration of outage to withstand
- # and % of Critical, Priority and Discretionary loads served
  - # of Critical Facilities
  - # of Emergency Services
  - # of Critical Infrastructure
  - # of Community Resource Centers
  - # of Essential Services
  - # of Cumulative Customers without power

Resiliency Valuation Methodology
I. Baseline Assessment

1. Define Geographical Area of Study

- Each area of consideration has **unique location-based considerations** of hazards, resources, and demographics.
- **Collaboration** between local and tribal governments and utilities **is critically important.**
- **Local & Tribal governments understand their communities needs best**, have knowledge of critical infrastructure, Emergency planning, Hazard Mitigation Plans, zoning, business and residential development plans, economic dynamics, and socio-economic impacts.
- Location based mapping can result in **optimized resiliency planning**.

Resiliency Valuation Methodology
I. Baseline Assessment

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  - # of Community Resource Centers
  - # of Essential Services
  - # of Cumulative Customers without power

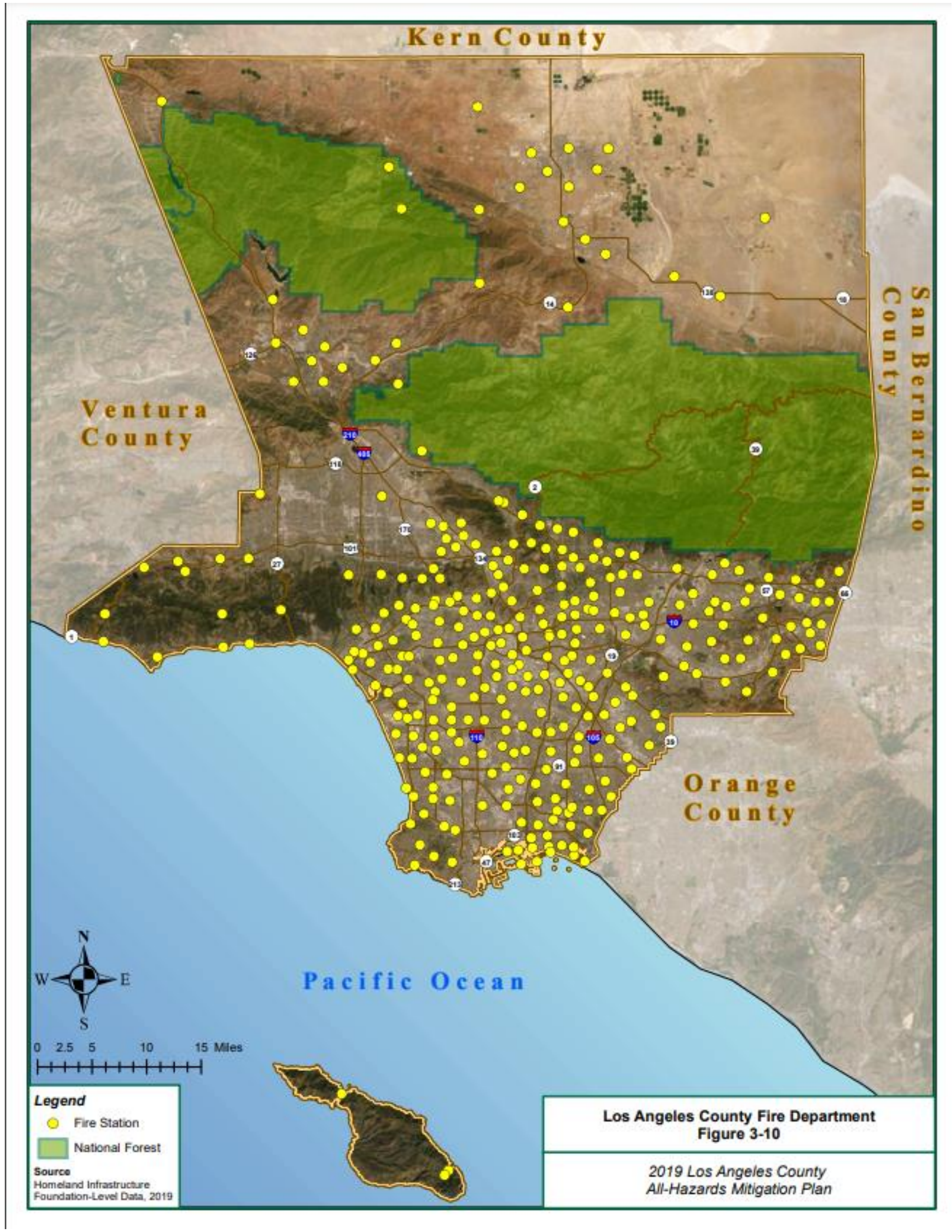
Resiliency Valuation Methodology
I. Baseline Assessment

2. Define Load Tier Assets: Critical, Priority, Discretionary

- Load Tier Assets should reflect resiliency priorities and goals
  ➔ **Electric utilities** may **prioritize** electric utility **infrastructure**
  ➔ **Local/Tribal government** may **prioritize community/societal resiliency**

- **Resiliency metrics will pivot off these defined Load Tiers**

Critical loads	Critical Facilities , Emergency 1st Responders, Community Resource Centers, Charging stations, evacuation centers, hospitals, critical infrastructure (water, waste-water, natural gas, communication, transportation, data centers), local and tribal government buildings
Priority loads	Essential services such as gas stations, charging stations, banks, food supply chain: grocery stores, food distribution centers, agricultural centers, restaurants), minimum load to residents to maintain refrigeration, critical infrastructure not included as Critical Facilities (data centers, water delivery system, waste, communication and transportation systems)
Discretionary loads	All other loads ➔ Commercial/Industrial, Retail stores, residential neighborhoods, recreational centers



Resiliency Valuation Methodology
I. Baseline Assessment

Based on:
- Electrical infrastructure
- City or County Lines
- Project scope
- Local/Tribal Gov't Hazard Mitigation plans

Identify:
- Resource availability/ limitations such as land available, zoning, current generation and/or storage
- Commercial and industrial economy
- Wealth disparities
- Population demographics and needs

Map:
- Critical Facilities, Critical Infrastructure, Essential service assets, C & I, retail, residential

1. Define Geographical Area of Study

2. Define Load Tier Assets: Critical, Priority, Discretionary

Load Tier assets example:
- Critical:
  Critical Facilities, Critical Infrastructure, Medical Baseline, Emergency 1st Responder systems, DAC, VC, Food Banks, Evacuation Centers
- Priority
  Essential services such as gas stations, charging stations, banks, food supply chain: grocery stores, food distribution centers, agricultural centers
- Discretionary
  Commercial/Industrial, Retail stores, residential neighborhoods, recreational centers

- Who defines what is in these Load Tier assets? Collaboration between:
  - ❖ Local Government/Tribes
  - ❖ IOUs
  - ❖ Developers

3. Identify Resiliency Targets in Load Tiers

- Resilience duration required
- Maximum duration of outage to withstand
- # and % of Critical, Priority and Discretionary loads served
  - # of Critical Facilities
  - # of Emergency Services
  - # of Critical Infrastructure
  - # of Community Resource Centers
  - # of Essential Services
  - # of Cumulative Customers without power

Resiliency Valuation Methodology
I. Baseline Assessment

3. Identify Resiliency Targets – Measurements of Performance Based Design

A minimum level of resiliency could be defined as maintaining Critical Tier load levels for a defined duration.

When comparing resiliency measures to maintain power within the defined geographical area during a disruption event, **the level of public benefit provided within that geographical area could be quantified by noting**:

- # of Critical Facilities supported at X% of load level
- # of Community Resource Centers at X% of load level
- # of Charging stations (cars, laptops, phones) with Y capacity of charging[1]
- # food storage/prep facilities available (freezers, fridge, grocery stores, restaurants, food banks)
- # of banks, gas stations
- # of other facilities providing social continuity (schools, preschools, daycare, businesses)

[1] As V2B technology becomes adopted, this charging capacity can present both load requirement and mobile generation which could also expand the effective geographical boundary of public benefit of the mitigation measure being studied.

We want to show that:

1. **Community resiliency has improved**,
2. But we also want to show **the mitigation measure chosen has the highest resiliency capacity against the most potential hazards**,
3. And we want **the cost-effectiveness measure to indicate what that resiliency capacity costs** so that when choosing resiliency mitigation measures, we are **balancing cost with resiliency capacity**.
4. **GHG and PM levels** over time (over what time are they emitted) with these resiliency measures would factor in as a ranking attribute.
5. The contributions of the mitigation measure to **"Blue Sky" operations** would also be factored in as a ranking attribute. This attribute would be ranked by **how much the measure contributes to grid and state policy goals**. Does it contribute to DER goals? Does it reduce utility infrastructure investment? Does it reduce ratepayer costs? Does it reduce DAC, L-I community rates? Does it contribute to eliminating racism and balancing equity in the energy system? Does its installation and operation contribute to the local economy?

Resiliency Valuation Methodology
I. Baseline Assessment

3. Identify Resiliency Targets – Measurements of Performance Based Design

Resiliency Metrics List - DRAFT

The metrics below are a preliminary list of potential metrics to be used to determine a Baseline Assessment of resiliency, as well as assess the effectiveness of mitigation measures designed to increase resilience.

- **Geographical boundaries**
- **Performance data**
  - Expected Energy Not Served (EENS)
  - CAIDI/CAIFI
  - MGs in area - pre/post disruption: duration, Energy served, energy not served, CF/services included in load
  - Circuit load profiles (blue sky)
  - Circuit reliability metrics w/MED, planned outages and ISO outages, PSPS outages
  - Data from the Rotating Outage report that may have relevance for resiliency reporting such as:
    - Substation areas - this is more for everyone
    - Mid feeder areas -- who stayed online, who would have lost power, how many customers in what category, and CF, CRC
- **Outage (Islanded) performance:**
  - Outage (islanded) performance on circuit by circuit basis
  - How much of the load are they picking up?
  - If any load curtailment:
    - How did they curtail? (utility driven or customer cooperation?)
    - How did they choose to curtail what they did? (Load Tier assets – Critical, Priority, Discretionary)
  - What durations did they experience?
  - Cause of outage?
  - How many outages/when in the last 1 yr, 3 yr, 5yr?

Resiliency Valuation Methodology
I. Baseline Assessment

3. Identify Resiliency Targets – Measurements of Performance Based Design

Resiliency Metrics List - DRAFT

The metrics below are a preliminary list of potential metrics to be used to determine a Baseline Assessment of resiliency, as well as assess the effectiveness of mitigation measures designed to increase resilience.

- **Community Data**
  - # of residential customers
  - # of non-residential customers
  - # of Medical Baseline, DAC, VC, LI
  - SGIP data maps
  - Tribal population data and geography
  - Local governments affected/geographical areas
  - Median income
  - Food Bank data
  - Business (Comm/Indus/Retail)
    - Revenue and/or production costs
    - Lag time in recovery of costs
  - Customer outage costs vs Utility outage costs – Value of Service or Value of Lost Load
  - Any data on non-MG participants that used power or the assets powered within the MG during any of these outages?

- **Community Outage Impact Data**
  - Cumulative daily # of customers without power / served with MG
  - # of Critical Facilities, Community Resource Centers, Emergency 1st Responder resources without power / served with MG

Resiliency Valuation Methodology
I. Baseline Assessment

3. Identify Resiliency Targets – Measurements of Performance Based Design

Resiliency Metrics List - DRAFT

The metrics below are a preliminary list of potential metrics to be used to determine a Baseline Assessment of resiliency, as well as assess the effectiveness of mitigation measures designed to increase resilience.

- **Infrastructure Data**
  - ENERGY infrastructure:
    - Energy infrastructure - substations, Transmission, circuits, distribution feeders
    - EV charging infrastructure
    - Current energy generation resources
    - Current energy storage resources
    - Fuel Type/source
    - GHG emission data?
  - COMMUNITY Infrastructure:
    - #, location and load of Critical Facilities, Community Resource Centers, Emergency 1st Responder resources
    - #, location and load of essential services (food supply chain, gas, EV (see below), banks, pharmacies, schools/childcare)
    - Location and load of Critical Infrastructure (other than energy)– water (emergency response and potable), telecommunications, transportation

- **Mitigation Measure Options**
  - CapEx and O&M costs of mitigation measures they considered
  - Comparative recovery costs before and after mitigation measure implementation

Resiliency Valuation Methodology
I. Baseline Assessment

- **For defined geographical area:**
- Determine primary disruptive hazards within geographical scope, apply weightings and rankings according to probability, magnitude, geographical impact and economic impact
  - Climate Change hazards such as:
  - Extreme weather,
  - Sea level rise
  - Cybersecurity hazards
  - Physical attack hazards

- Identify impact on Load Tier Assets

- Who conducts all-Hazard assessment?:
  - Cities, Counties, Local Government
    - Hazard Mitigation Plans
    - UNDDR Disaster Resilience Framework for Cities/Counties
  - IOUs
    - RAMP (modified)

4. Conduct All-Hazard Assessment for defined geographical area

5. Conduct current Resiliency Assessment baseline of Load Tiers

For each hazard (in ranking/ weighted order):

- Graph *historical* load not served (CAIDI w/MED) over time for geographical scope
- Graph *projected* load not served (CAIDI w/MED) over time for geographical scope
- Identify impacts on resiliency targets
- Evaluate utility costs of Energy Not Served
- Evaluate public costs of Energy Not Served
  - ❖ Interruption Cost Estimator (ICE)*
  - ❖ Value of Service estimates*

  * with updated surveys

6. Results of Resiliency Baseline Assessment

From results of Baseline Assessment:

- Identify priority resilience deficits
- Identify resilience priorities
- Identify resilience metrics to assessment mitigation impacts

Hazards to Mitigate with Resiliency Measures

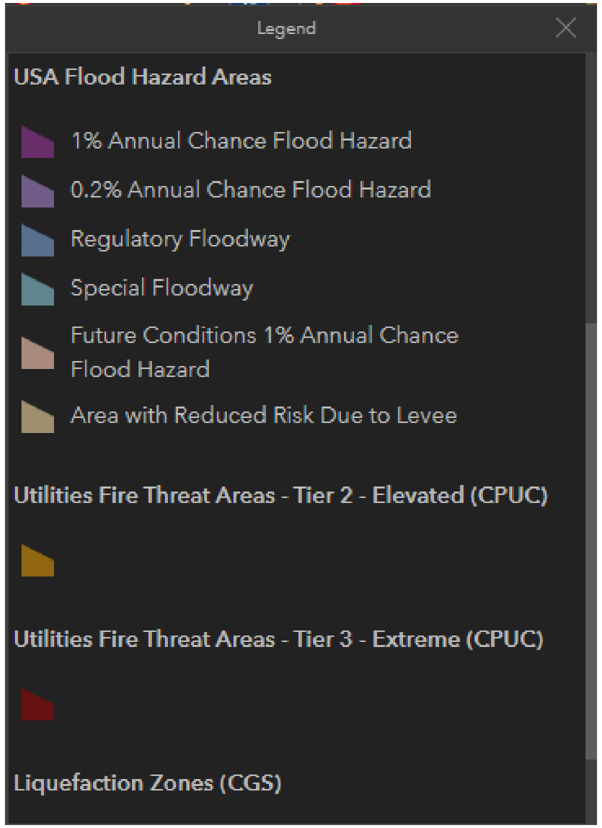
Nevada County
Local Hazard Mitigation Plan Update
August 2017

United Nations Office for Disaster Risk Reduction (UNDRR) – **Disaster Resilience Scorecard for Cities - Quick Risk Estimator tool:** provides a framework for local governments to assess hazards unique to their area.

Table ES-2 Nevada County Hazard Identification Assessment

Hazard	Geographic Extent	Probability of Future Occurrences	Magnitude/ Severity	Significance	Climate Change Influence
Ag Hazards: Severe Weather/Insect Pests	Significant	Highly Likely	Critical	High	High
Avalanche	Limited	Highly likely	Negligible	Low	Low
Climate Change	Extensive	Likely	Critical	Medium	High
Dam Failure	Significant	Occasional	Catastrophic	High	Low
Drought and Water Shortage	Extensive	Likely/ Occasional	Critical	Medium	Low
Earthquake	Extensive	Unlikely	Critical	Medium	Low
Flood: 100/500–year	Extensive	Occasional/Unlikely	Critical	High	Medium
Flood: Localized/Stormwater	Significant	Highly Likely	Limited	Medium	Medium
Hazardous Materials Transportation (interstates, railroads, pipelines)	Limited	Likely	Limited	Medium	Low
Landslide, Debris & Mud Flows	Significant	Likely	Critical	Medium	Low
Levee Failure	Limited	Unlikely	Limited	Low	Low
Severe Weather: Extreme Cold, Snow, and Freeze	Significant	Highly Likely	Limited	Medium	Medium
Severe Weather: Extreme Heat	Significant	Likely	Critical	Medium	Medium
Severe Weather: Heavy Rains and Storms (wind/tornado/hail, lightning)	Significant	Highly Likely	Critical	Medium	High
Subsidence	Significant	Likely	Negligible	Medium	Medium
Volcano	Significant	Unlikely	Limited	Low	Low
Wildfire (smoke, tree mortality, conflagration)	Extensive	Highly Likely	Catastrophic	High	High

Hazards to Mitigate with Resiliency Measures



Risk Assessment Mitigation Phase (RAMP)

SCE WMP Proposed Mitigation Measures & Budgets

SCE RAMP Proposed Mitigation Measures, Budgets, Risk Impacts and RSE

Capital Investments

Wildfire Mitigation Plan Proposed Mitigations					RAMP Wildfire Mitigations										
							Implementation Period		Cost Estimates ($M)		Expected Mean Value (MARS)		Tail Average (MARS)		
	SB901 Activity Identifier	Activity/Program	Capital Cost 2019 ($M) ($Nominal)(2019 Goal)	O&M Cost 2019 ($M) ($Nominal)(2019 Goal)	ID	Name	Start Year	End Year	Capital	O&M	MRR	RSE	MRR	RSE	
D&C	AT-1	Alternative Technology Pilots	0.2	NA											
D&C	AT-2	GSRP Wildfire Mitigation Program Study	NA	0.6											
D&C	AT-3	Alternative Technology Evaluations	NA	0											
D&C	AT-4	Alternative Technology Implementation	NA												
I&M	IN-1	Distribution Enhanced Overhead Inspections and Remediation in HFRA	302.8	144.9											
I&M	IN-2	Transmission Enhanced Overhead Inspections and Remediation in HFRA	9.9	25											
I&M	IN-3	Quality Oversight/Quality Control of EOI	NA												
I&M	IN-4	Infrared inspection of energized overhead distribution facilities and equipment	NA	0.5	M4	Infrared Inspection Program	2018	2023	x	$3	0.29	0.1029	0.95	0.3321	
I&M	IN-5	Infrared inspection, corona scanning and high definition imagery of energized overhead transmission facilities and equipment	NA	5.7											
I&M	NA	AGP - Drvie by of overhead distribution facilities and equipment	NA												
D&C	NA	Automatic Reclosers Replacement Program	2.4	NA	M2	Remote-controlled Automatic Reclosers and I	2018	2019	$28	$3	0.97	0.0311	1.35	0.1075	
D&C	NA	Capacitor Bank Replacement Program	18.1	NA											
I&M	NA	Detailed inspection of Transmission facilities and equipment	NA	5.7	M8	Fusing Mitigation	2018	2020	$68	$23	0.23	0.0025	0.74	0.0081	
I&M	NA	Deteriorated Pole Program	251.2	NA											
I&M	NA	Insulator Washing	NA	1.2											
I&M	NA	IPI - Intrusive pole inspections to identify rot and decay	NA	6.1											
I&M	NA	ODI - Detailed inspections of Distribution overhead faciltieis and equipment	NA	8.6											
D&C	NA	Overhead Conductor Program	143.9	NA	C1	Overhead Conductor Program (Bare & Covere	2018	2023	$102	x	0.09	0.0009	0.3	0.003	
D&C	NA	PCB Transformers Replacement Program	1.5	NA	C2	FR Overhead Distribution Transformer	2018	2023	$81	x	0.06	0.0007	0.18	0.0022	
OP	NA	Performance of joint patrols with fire agencies	NA												?
I&M	NA	Pole Brushing	NA												
I&M	NA	Pole Loading Program	NA	26.4											?
OP	NA	PSPS/De-energization Protocol Support Costs	NA	4.3											
I&M	NA	Road and Right-of-Way Maintenance	NA	3.9											
I&M	NA	Substation Inspection and Maintenance	NA	2.2											
I&M	NA	Supplemental inspections of HFRA	NA	69.1 Distribution 11.3 Transmission											
I&M	NA	Transmission Line Rating Remediation	157.9	8.2											?
OP	OP-1	Annual SOB 322 Review	NA												
OP	OP-2	Wildfire Infrastructure Protection Team Additional Staffing	NA	0.5											
OP	PSPS-1	De-Energization Notifications	NA	1.3	M3	PSPS Protocol and Support Functions	2018	2023	x	$21	1.90	0.0892	6.66	0.3119	
SCA	SA-1	Additional Weather Stations	5.4	0.6	M7	Enhanced Situational Awareness	2018	2023	$31	$26	0.84	0.0149	3.19	0.0561	
SCA	SA-2	Fire Potential Index Phase II	NA	0.6											
SCA	SA-3	Additional HD Cameras	2.3	2.6											
SCA	SA-4	High-performing Computer Weather Modeling System	3.8	0.1											
SCA	SA-5	Develop Asset Reliability and Risk Analytics Capability	0.5	NA											
D&C	SH-1	Covered Conductor	47.4	1.0	M1	Wildfire Covered Conductor Program	2018	2023	$1,161	x	1.64	0.0014	5.28	0.0045	
D&C	SH-2	Evaluation of Undergrounding in HFRA	0	0											
D&C	SH-3	Composite Poles and Crossarms	5.1	0.1	M9	Fire Resistant Poles (M1 Scope)	2018	2023	$137	x	0.60	0.0044	2.26	0.0165	
D&C	SH-4	Branch Line Protection Strategy	46.1	0.9											
D&C	SH-5	Remote Controlled Automatic Reclosers Installations	4.9	0.1											
D&C	SH-6	Remote Controlled Automatic Reclosers Setting Updates	NA	0.3											
D&C	SH-7	Circuit Breaker Fast Curve	9.1	0.2											
I&M	VM-1	Hazard Tree Mitigation Program (HTMP)	NA	25.5	M5	Expanded Vegetation Management	2018	2023	x	$370	0.38	0.001	1.23	0.0033	
I&M	VM-2	Expanded Pole Brushing	NA	0.9											
I&M	VM-3	Expanded Clearance distances at time of maintenance	NA	28.0											
I&M	VM-4	DRI quarterly inspections and removals	NA	41.5											
I&M	VM-5	LIDAR inspections of Transmission	NA	3.7											
		TOTALS	$812.5	$351.2					$1,609	$447	7.02	0.0034	24.14	0.0117	

WMP Color Legend	no. of tasks	Capital ($M)	O&M ($M)
Design & Construction (D&C)	15	$278.7	$3.2
Inspection and Maintenance (I&M)	22	$521.8	$334.1
Operational Practices (OP)	2	$0.0	$6.1
Situational/Conditional Awareness (SCA)	5	$12.0	$3.9
Response and Recovery (R&R)	0	$0.0	$0.0
	44	$812.5	$347.3

44 mitigations

10 mitigations

Resiliency Valuation Methodology
I. Baseline Assessment

For defined geographical area:

- Determine primary disruptive hazards within geographical scope, apply weightings and rankings according to probability, magnitude, geographical impact and economic impact
  - Climate Change hazards such as:
  - Extreme weather,
  - Sea level rise
  - Cybersecurity hazards
  - Physical attack hazards
- Identify impact on Load Tier Assets
- Who conducts all-Hazard assessment?:
  - Cities, Counties, Local Government
    - Hazard Mitigation Plans
    - UNDDR Disaster Resilience Framework for Cities/Counties
  - IOUs
  - RAMP (modified)

4. Conduct All-Hazard Assessment for defined geographical area

5. Conduct current Resiliency Assessment baseline of Load Tiers

For each hazard (in ranking/ weighted order):

- Graph *historical* load not served (CAIDI w/MED) over time for geographical scope
- Graph *projected* load not served (CAIDI w/MED) over time for geographical scope
- Identify impacts on resiliency targets
- Evaluate utility costs of Energy Not Served
- Evaluate public costs of Energy Not Served
  - ❖ Interruption Cost Estimator (ICE)*
  - ❖ Value of Service estimates*

  * with updated surveys

From results of Baseline Assessment:

- Identify priority resilience deficits
- Identify resilience priorities
- Identify resilience metrics to assessment mitigation impacts

6. Results of Resiliency Baseline Assessment

Resiliency Valuation Methodology
I. Baseline Assessment

5. Conduct Current Resiliency Assessment - Baseline of Load Tiers

For each hazard (in ranking/ weighted order):

- Graph *historical* load not served (CAIDI w/MED) over time for geographical scope
- Graph *projected* load not served (CAIDI w/MED) over time for geographical scope
- Identify impacts on resiliency targets
- Evaluate **utility costs of Energy Not Served**
- Evaluate **public costs of Energy Not Served**
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    - Value of Service estimates *

* with updated surveys

Resiliency Valuation Methodology
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6. Results of Resiliency Baseline Assessment

Resiliency Valuation Methodology
I. Baseline Assessment

6. Results of Resiliency Baseline Assessment

From results of Baseline Assessment:
•Identify priority resilience deficits
•Identify resilience priorities
•Identify resilience metrics to assessment mitigation impacts

Resiliency Valuation Methodology

4 Pillars of Resiliency Valuation – The Details

I. Baseline Assessment

II. Mitigation Measure Assessment

III. Resiliency Scorecard

IV. Resiliency Response Assessment (post-disruption)

Resiliency Valuation Methodology
II. Mitigation Measure Assessment

- Using Resiliency Targets as guidelines develop mitigation measure options
- Identify Mitigation Measure Characteristics
- Identify costs (CapEx and O&M)

1. Identify Mitigation Measure Options

2. Assess ability of mitigation measures to reach Resiliency Targets for Hazards (in ranking order)

- Identify ability of Mitigation Measure to reach Resiliency Targets
  - ❖ Resilience duration required
  - ❖ Maximum duration of outage to withstand
  - ❖ # and % of Critical, Priority and Discretionary loads served
  - ❖ # of Critical Facilities
  - ❖ # of Emergency Services
  - ❖ # of Critical Infrastructure
  - ❖ # of Community Resource Centers
  - ❖ # of Essential Services
  - ❖ # of Cumulative Customers without power

- Identify Risk-Spend Efficiency levels of Mitigation Measure Options according to highest level of Resiliency Targets met for highest ranking Hazards
- Combine Resiliency Scorecard results with All-Hazard Mitigation Analysis in comparison of Mitigation Measure Options

3. Compare costs of Mitigation Measures Options that achieve highest level of Resilience

Resilience Mitigation Measure Characteristics

Mitigation Measure Characteristic	Metric
Start-up or islanding crossover transition time (intermittent downtime before specified backup is available)	Time – minutes, hrs
Notification time/Advanced notice needed for backup available at specified load/duration	Time – minutes, hrs
Duration of backup – with no other inputs	Time – minutes, hrs
Load Capacity (which loads are backed up and how much load (Critical, Priority, Discretionary)	kWh, MWh
Fuel Type/Fuel Availability	Unit of fuel, availability before/during islanding
Emissions level – GHG and particulates	MMCO2, PPM
Geographic boundary	Location on geographic map, sq ft, sq mi

Resiliency Valuation Methodology
II. Mitigation Measure Assessment

- Using Resiliency Targets as guidelines develop mitigation measure options
- Identify Mitigation Measure Characteristics
- Identify costs (CapEx and O&M)

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  - ❖ # of Cumulative Customers without power

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Resiliency Valuation Methodology
II. Mitigation Measure Assessment

1. Identify Mitigation Measure Options

- Using Resiliency Targets as guidelines develop mitigation measure options
- Identify Mitigation Measure Characteristics
- Identify costs (CapEx and O&M)

2. Assess ability of mitigation measures to reach Resiliency Targets for Hazards (in ranking order)

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  - ❖ # of Emergency Services
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  - ❖ # of Community Resource Centers
  - ❖ # of Essential Services
  - ❖ # of Cumulative Customers without power

3. Compare costs of Mitigation Measures Options that achieve highest level of Resilience

- Identify Risk-Spend Efficiency levels of Mitigation Measure Options according to highest level of Resiliency Targets met for highest ranking Hazards
- Combine Resiliency Scorecard results with All-Hazard Mitigation Analysis in comparison of Mitigation Measure Options

All-Hazard Approach to Assess Resiliency Measures

Mitigation measures to achieve the minimum resilience level for the geographic area defined would be compared in terms of cost, effectiveness (based on the effect on the resiliency trapezoid and/or meeting resiliency targets) and the degree to which the measure would mitigate various hazards (risk-assessment based on weighted all-hazard probability and impact analysis). This type of mitigation measure comparison may reveal vulnerabilities and benefits previously unrealized.

As an example:

i. Measure A mitigates Hazard Z
ii. Measure B mitigates Hazard Z & Y
iii. Measure C mitigates Hazard X
iv. Measure D mitigates Z, Y & X
v. Measure D offers highest level of resilience -- at what cost?
vi. Compare with costs of either Meas. A + Meas B. + Meas. D OR Meas B + Meas. D
vii. Compare with Resilience Measure Characteristics (notification, crossover, duration, fuel type, load capacity, emissions, geographical impact)

Measure	Mitigates Hazard	Ranking	Cost *	Resiliency Trapezoid
A	Z	1	$40,000	Preparation
B	Z, Y	2	$100,000	Preparation/Magnitude
C	X	1	$400,000	Adaptation/Recovery
D	Z, Y, X	3	$520,000	Preparation (Z, Y), Magnitude (Y), Adaptation (X), Recovery (X)

*Cost figures are arbitrary and for illustration purposes only

Resiliency Valuation Methodology

4 Pillars of Resiliency Valuation – The Details

I. Baseline Assessment
II. Mitigation Measure Assessment
III. Resiliency Scorecard
IV. Resiliency Response Assessment (post-disruption)

Resiliency Valuation Methodology
III. Resiliency Scorecard

Resiliency "Scorecard"

1) Resiliency Scorecard is a tool that aims to provide a mechanism for comparing resiliency solution configurations that recognizes a basic benchmark of achievement and provides for improvement.

2) Scoring system provides for different areas of (potentially ongoing) 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 which would result in a higher "score").

3) Areas to be scored and scoring mechanisms could be determined by a Resiliency Scorecard Working Group. Review and updates of the Scorecard could happen periodically (e.g. every 3 yrs) to capture acknowledgement of Scorecard effectiveness, changing technologies and a changing energy environment.

Resiliency Valuation Methodology
III. Resiliency Scorecard (draft)

Resiliency Scorecard: Mitigation Measure Characteristics	Points	Score
Duration of backup – with no other inputs		
4 hrs	1	
8 hrs	2	
24 hrs	3	
48 hrs (2 days)	4	
96 hrs (4 days)	5	
Indefinite	6	
Load Capacity (which loads are backed up and how much load (Critical, Priority, Discretionary)		
Critical		
90 - 100%	9	
50 - 90%	8	
0 – 50%	7	
Priority		
90 - 100%	6	
50 - 90%	5	
0 – 50%	4	
Discretionary		
90 - 100%	3	
50 - 90%	2	
0 – 50%	1	

Resiliency Scorecard: Mitigation Measure Characteristics	Points	Score
Fuel Availability		
Onsite, intermittent	3	
Onsite, produced	3	
Piped infrastructure	2	
Wires infrastructure	2	
Transport	1	
Emissions level – GHG and particulates		
Non-GHG emitting	4	
Meets CARB emission standards	3	
GHG emissions < xxx	2	
Cap n Trade	1	

Resiliency Scorecard: Mitigation Measure Characteristics	Points	Score
Start-up/ islanding /isolation/ crossover transition time (intermittent downtime before specified backup is available)		
0 - 1 min	5	
2 - 5 min	4	
5 - 30 min	3	
30 - 120 min	2	
< 120 min	1	
Notification time/Advanced notice needed for backup available at specified load/duration		
0 - 1 min	5	
2 - 5 min	4	
5 - 30 min	3	
30 - 120 min	2	
< 120 min	1	
Blue Sky Services		
Demand Response	2	
Voltage/Frequency	1	
Wholesale participation	1	

Resiliency Valuation Methodology

4 Pillars of Resiliency Valuation – The Details

I. Baseline Assessment
II. Mitigation Measure Assessment
III. Resiliency Scorecard
IV. Resiliency Response Assessment (post-disruption)

Resiliency Valuation Methodology
IV. Resiliency Response Assessment

- Conduct Baseline Assessment (1-6) pre-implementation of mitigation measure

1. Identify Mitigation Measure Options

2. Annual (?) update of Baseline Assessment to capture changes

- After implementation of chosen mitigation measure option, conduct annual data collection of Resiliency Metrics

- In Planning stage use computer modeling to assess achievement of resiliency targets
- During and post disruption event, collect data to reflect achievement of resiliency targets

3. Assess achievement of Resiliency Targets

Resiliency Valuation Methodology
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Resiliency Valuation Methodology
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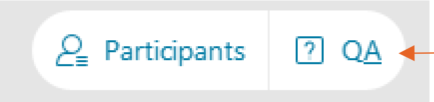
Next Steps: Applying the Methodology to Evaluate Resiliency

- Application --
  - ❖ What tools currently exist or are in development that can be applied?
  - ❖ Should the Commission undertake an initiative to apply this methodology to existing microgrids?
- Equity --
  - ❖ How can we ensure these metrics are not biased and are focused on equity?
  - ❖ How can metrics like median income and percentage of median income be used to more realistically inform understanding of the accumulations of risk and impacts?
  - ❖ How can we use data and metrics to ensure we are focusing on communities in need and compensating resiliency measures in a way that promotes them in DAC
- Policy --
  - ❖ Are public, ratepayer benefits accrued when providing backup to customers when the grid is de-energized?
  - ❖ Who should get to make the decision on what to pay on behalf of whom?
  - ❖ Who is exercising that subjective value judgment? CPUC? Individual households? Local governments?
  - ❖ What is reasonable?

Discussion and Q&A

WebEx Tip

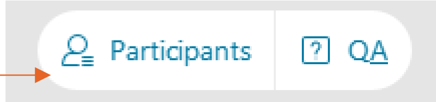
Option 1:



Access the written Q&A panel here

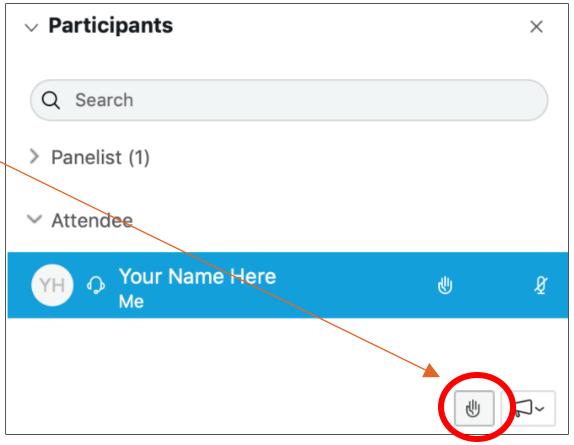
Option 2:

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.



Upcoming Meetings

- **Wednesday, May 12, 2021, 3-4:30PM**
  Topic: Value of Resiliency – Interruption Cost Estimator (ICE), presentation by Lawrence Berkeley Labs

- **Wednesday, May 19, 2021, 2-4PM**
  Topic: Value of Resiliency – Pillar I: Baseline Assessment, additional presentations TBD

California Public Utilities Commission

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