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

Resiliency and Microgrids Team, Energy Division
May 5, 2021
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

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 the written Q&A panel here

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.

Event status: Not started (Register)
Date and time: Tuesday, March 2, 2021 9:30 am
Pacific Standard Time (San Francisco, GMT-08:00)

Duration: 1 hour

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

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.
### Preliminary Resiliency & Microgrids Working Group Schedule

<table>
<thead>
<tr>
<th>Month</th>
<th>Resiliency and Microgrids Working Group Topics</th>
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</thead>
<tbody>
<tr>
<td>February</td>
<td>Standby Charges</td>
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<td>Multi-Property Microgrid Tariff</td>
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<td>Value of Resiliency</td>
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<td>March</td>
<td>Multi-Property Microgrid Tariff</td>
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<td>April</td>
<td>Multi-Property Microgrid Tariff</td>
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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

- Ensure access to affordable, reliable, sustainable and modern energy for all
- Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
- 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**.
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.

![Graph showing number of Extreme Heat Days by Year](image)

- **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 Climate Explorer

Sonoma County, CA

Sonoma County, CA Avg Daily Max Temp (°F)

Average Daily Max Temp (°F)

Chart | Map | Annual | Monthly | Downloads | About the graph

Historical Observed | Historical Modeled | Lower Emissions | Higher Emissions

1950 to 2099
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.”

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

$ 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.

<table>
<thead>
<tr>
<th>Metric</th>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SAIDI</strong></td>
<td>$\frac{\text{Total minutes every customer was without power due to sustained outages}}{\text{Total number of customers}}$</td>
<td>Number of minutes customers were without power due to sustained outages.</td>
</tr>
<tr>
<td><strong>SAIFI</strong></td>
<td>$\frac{\text{Number of sustained customer outages experienced by all customers}}{\text{Total number of customers}}$</td>
<td>Number of sustained outages experienced by all customers.</td>
</tr>
<tr>
<td><strong>CAIDI</strong></td>
<td>$\frac{\text{System Average Interruption Duration Index (SAIDI)}}{\text{System Average Interruption Frequency Index (SAIFI)}}$</td>
<td>Ratio of SAIDI to SAIFI.</td>
</tr>
<tr>
<td><strong>MAIFI</strong></td>
<td>$\frac{\text{Number of customers who experience Momentary Outages}}{\text{Total number of customers}}$</td>
<td>Number of customers who experience momentary outages.</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Without MED (minutes)</th>
<th>PG&amp;E 2019 SAIDI</th>
<th>PG&amp;E 2018 SAIDI</th>
<th>2019 National Average SAIDI</th>
<th>San Francisco Division SAIDI</th>
<th>Humboldt Division SAIDI</th>
</tr>
</thead>
<tbody>
<tr>
<td>117.7</td>
<td>99.9</td>
<td>133.3</td>
<td>56.8</td>
<td>274.6</td>
<td></td>
</tr>
<tr>
<td>With MED (Minutes)</td>
<td>1365.1</td>
<td>282.9</td>
<td>263.8</td>
<td>71.6</td>
<td>6899.9</td>
</tr>
</tbody>
</table>
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?
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.

Discussion and Q&A

WebEx Tip

Option 1:
Access the written Q&A panel here

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

<table>
<thead>
<tr>
<th>Critical loads</th>
<th>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</th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority loads</td>
<td>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)</td>
</tr>
<tr>
<td>Discretionary loads</td>
<td>All other loads ➔ Commercial/Industrial, Retail stores, residential neighborhoods, recreational centers</td>
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  • # 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

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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

1. Define 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)

2. 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
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.
Hazards to Mitigate with Resiliency Measures
Risk Assessment Mitigation Phase (RAMP)

<table>
<thead>
<tr>
<th>SCE WMP Proposed Mitigation Measures &amp; Budgets</th>
<th>SCE RAMP Proposed Mitigation Measures, Budgets, Risk Impacts and RSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Investments</td>
<td>Capital Investments</td>
</tr>
<tr>
<td>Name</td>
<td>Name</td>
</tr>
<tr>
<td>Start Year</td>
<td>Start Year</td>
</tr>
<tr>
<td>End Year</td>
<td>End Year</td>
</tr>
<tr>
<td>Project Duration</td>
<td>Project Duration</td>
</tr>
<tr>
<td>Yearly Average</td>
<td>Yearly Average</td>
</tr>
<tr>
<td>Year 1</td>
<td>Year 2</td>
</tr>
</tbody>
</table>

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
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  - Value of Service estimates * with updated surveys

5. Conduct current Resiliency Assessment baseline of Load Tiers

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*
  • Interruption Cost Estimator (ICE)*
    ○ Value of Service estimates *

* with updated surveys
Resiliency Valuation Methodology

I. Baseline Assessment

4. Conduct All-Hazard Assessment for defined geographical area

- For defined geographical area:
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I. Baseline Assessment

6. Results of Resiliency Baseline Assessment

From results of Baseline Assessment:
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• 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

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)
   - 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

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
## Resilience Mitigation Measure Characteristics

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

1. Identify Mitigation Measure Options
   - Using Resiliency Targets as guidelines develop mitigation measure options
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     ❖ # of Critical Facilities
     ❖ # of Emergency Services
     ❖ # of Critical Infrastructure
     ❖ # of Community Resource Centers
     ❖ # of Essential Services
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All-Hazard Approach to Assess Resiliency Measures

Mitigation measures to achieve the minimum resiliency 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?
vii. Compare with Resilience Measure Characteristics (notification, crossover, duration, fuel type, load capacity, emissions, geographical impact)

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

*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 Scorecard (draft)

#### III. Resiliency Scorecard

<table>
<thead>
<tr>
<th>Resiliency Scorecard: Mitigation Measure Characteristics</th>
<th>Points</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of backup – with no other inputs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 hrs</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>8 hrs</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>24 hrs</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>48 hrs (2 days)</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>96 hrs (4 days)</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Indefinite</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Load Capacity (which loads are backed up and how much load (Critical, Priority, Discretionary))</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Critical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90 - 100%</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>50 - 90%</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>0 - 50%</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Priority</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90 - 100%</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>50 - 90%</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>0 - 50%</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Discretionary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90 - 100%</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>50 - 90%</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>0 - 50%</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Fuel Availability</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onsite, intermittent</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Onsite, produced</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Piped infrastructure</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Wires infrastructure</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Emissions level– GHG and particulates</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-GHG emitting</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Meets CARB emission standards</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>GHG emissions &lt; xxx</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Cap n Trade</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

### Resiliency Scorecard: Mitigation Measure Characteristics

<table>
<thead>
<tr>
<th>Start-up/ islanding /isolation/ crossover transition time (intermittent downtime before specified backup is available)</th>
<th>Points</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1 min</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2 - 5 min</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5 - 30 min</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>30 - 120 min</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&lt; 120 min</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Notification time/Advanced notice needed for backup available at specified load/duration</th>
<th>Points</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 1 min</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>2 - 5 min</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5 - 30 min</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>30 - 120 min</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>&lt; 120 min</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Blue Sky Services</th>
<th>Points</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand Response</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Voltage/Frequency</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Wholesale participation</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
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)
IV. Resiliency Response Assessment

1. Identify Mitigation Measure Options
   - Conduct Baseline Assessment (1-6) pre-implementation of mitigation measure

2. Annual (?) update of Baseline Assessment to capture changes
   - After implementation of chosen mitigation measure option, conduct annual data collection of Resiliency Metrics

3. Assess achievement of Resiliency Targets
   - 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
Resiliency Valuation Methodology
IV. Resiliency Response Assessment

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