Resiliency & Microgrids Working Group
Value of Resiliency – Interruption Cost Estimator

Resiliency and Microgrids Team, Energy Division

May 12, 2021

California Public Utilities Commission

WebEx and Call-In Information

Join by Computer:

https://cpuc.webex.com/cpuc/onstage/g.php?MTID=efa825b959b470c6cc44f16396045b474

Event Password: RMWG (case sensitive)

Meeting Number: 187 758 0749

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.

- This meeting will not be recorded and there will not be meeting minutes.

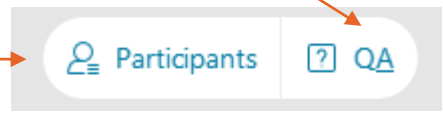
WebEx Logistics

- 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

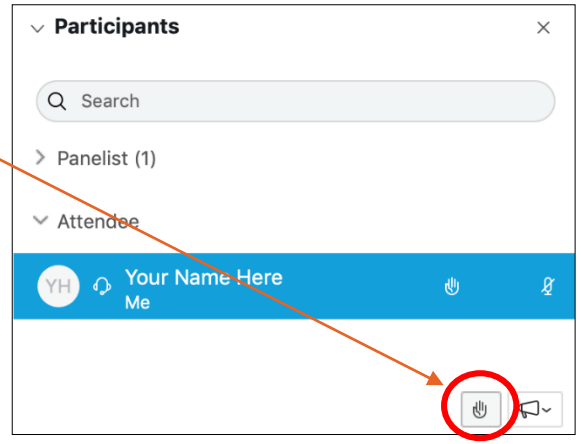
Access the written Q&A panel here

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.



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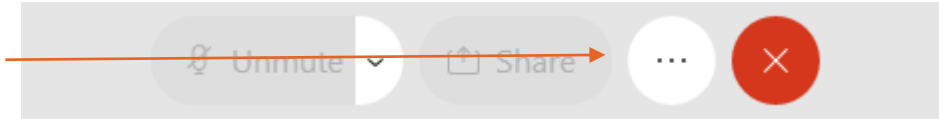
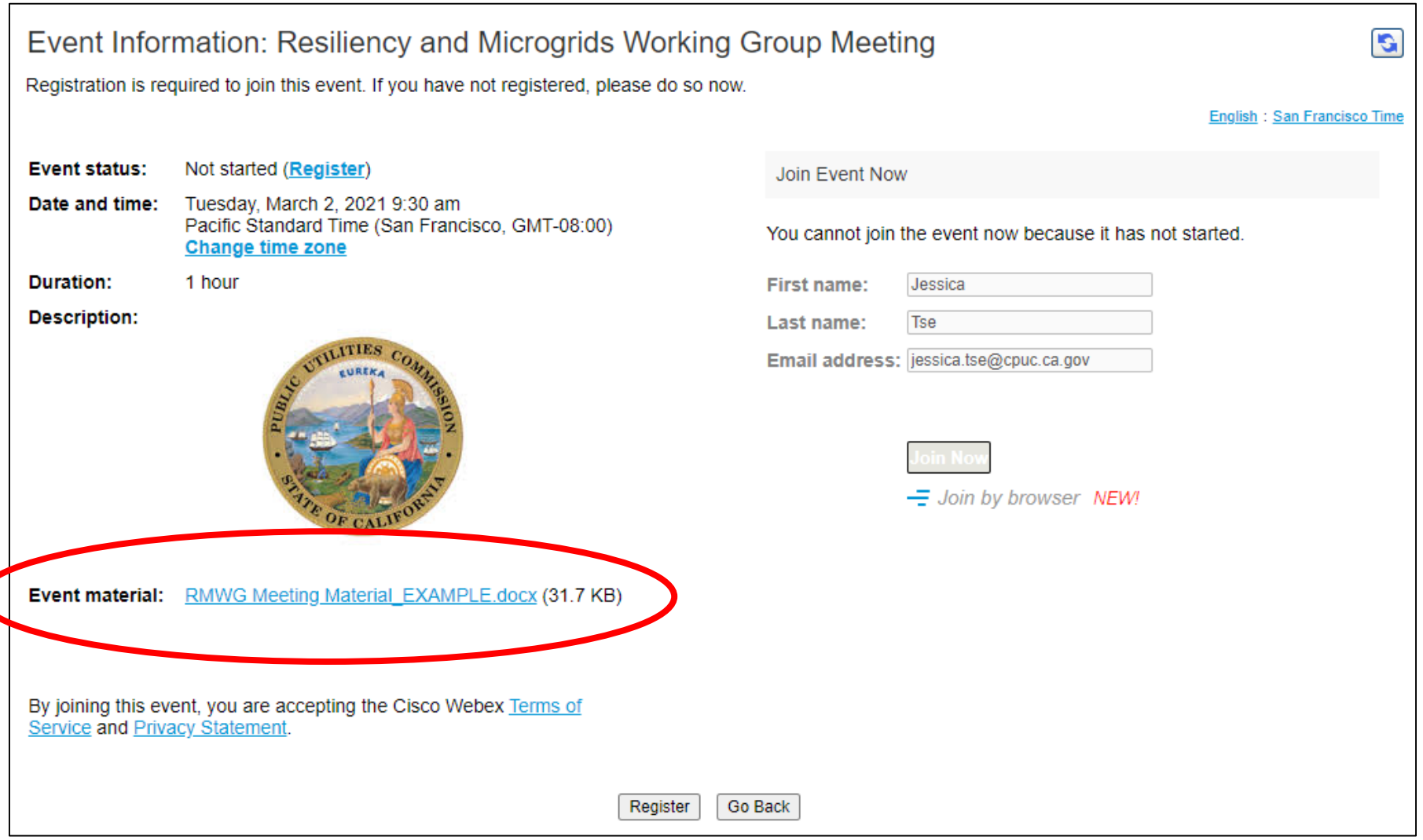


WebEx Event Materials



Preliminary Resiliency & Microgrids Working Group Schedule

Month	Resiliency and Microgrids Working Group Topics			
February	Standby Charges	Multi-Property Microgrid Tariff		
March				
April				
May			Value of Resiliency	
June				
July				
August				Microgrid Interconnection
September				
October				
November	Customer-Facing Microgrid Tariff Revisit			
December				
January				
February				

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) 3:00 – 2:05

- WebEx logistics, agenda review

II. Interruption Cost Estimator (ICE),
Joe Eto, Lawrence Berkeley National Labs 3:05 – 3:55

III. Q & A and Discussion 3:55 – 4:25

- Open Discussion

IV. Closing Remarks, Adjourn 4:25 – 4:30

- Provide information on the next meeting

Value of Resiliency
LBNL's Interruption Cost Estimate (ICE) Calculator

Joseph H. Eto

Lawrence Berkeley National Laboratory

Resiliency and Microgrids Working Group

California Public Utilities Commission

May 12, 2021

Reliability and Resilience Research at Berkeley Lab

Reliability and Resilience Metrics

- EIA Form-861: mandatory reliability reporting by all US electric utilities
- IEEE Distribution Reliability Working Group: technical review of IEEE Std. 1366 "major event day" classification
- NERC Performance Analysis Subcommittee: prepares annual State of Reliability report

Economic Value of Reliability and Resilience – *Today's discussion*

- Reliability versus resilience decision-making, including metrics
- Reliability value-based planning
- The Interruption Cost Estimate (ICE) Calculator
- New methods to estimate the customer costs of widespread, long-duration power interruptions

https://emp.lbl.gov/research/electricity-reliability

Reliability vs. Resilience: features, metrics, actions

	Reliability	Resilience
Common features/ characteristics	Routine, expected (though, not "planned"), normally localized, shorter duration interruptions of electric service Larger events will make it into the local headlines	Infrequent, unplanned, widespread/long duration power interruptions, often with significant corollary impacts Always national headline worthy
Metrics	Well-established, annualized (SAIDI, SAIFI, MAIFI), with provisions for "major events" Rarely include non-electricity impacts	Familiar, but non-standardized, and generally event-based (number of customers affected; hours without electric service) Routinely include non-electricity impacts (e.g., costs to firms; health and safety impacts)
Actions to improve	1. Plan and prepare; 2. Manage and endure event(s); 3. Recover and restore; and 4. Assess, learn, and update plan.	No qualitative difference But generally larger in scope/cost (see next slide)

Reliability vs. Resilience: decision-making

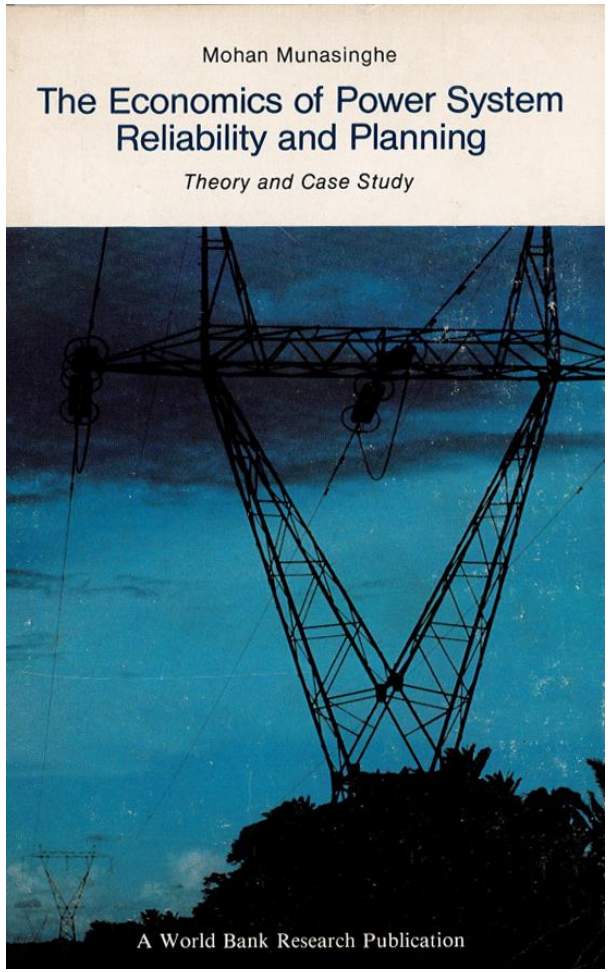
	Reliability	Resilience
Entities involved in decision making	Electric utility and its regulator/oversight board, primarily	Electric utility and regulator; many times, acting in response to State legislative direction or Governor's orders Routinely in conjunction with parties that have responsibilities for other critical infrastructures, including local/regional/state/federal agencies/authorities, and communities/elected officials
Factors affecting decision making	Actuarial records on frequency of exposure—widely understood risks: insurable Well-understood/tested practices/approaches Understood to be an expected cost of doing business	No actuarial basis to establish likelihood of occurrence—widely varying perceptions of risk/exposure: "un-insurable" risk Limited opportunities to test strategies in the field Large dollar amounts/extraordinary expenditures may require special approval/vote Political leadership critical

DOE Grid Modernization Lab Consortium metrics: Resilience

GMLC Resilience Metrics	Data Requirements
Cumulative customer-hours of outages	customer interruption duration (hours)
Cumulative customer energy demand not served	total kVA of load interrupted
Avg (or %) customers experiencing an outage during a specified time period	total kVA of load served
Cumulative critical customer-hours of outages	critical customer interruption duration
Critical customer energy demand not served	total kVA of load interrupted for critical customers
Avg (or %) of critical loads that experience an outage	total kVA of load severed to critical customers
Time to recovery	
Cost of recovery	
Loss of utility revenue	outage cost for utility ($)
Cost of grid damages (e.g., repair or replace lines, transformers)	total cost of equipment repair
Avoided outage cost	total kVA of interrupted load avoided
	$ / kVA
Critical services without power	number of critical services without power
	total number of critical services
Critical services without power after backup fails	total number of critical services with backup power
	duration of backup power for critical services
Loss of assets and perishables	
Business interruption costs	avg business losses per day (other than utility)
Impact on GMP or GRP	
Key production facilities w/o power	total number of key production facilities w/o power (how is this different from total kVA interrupted for critical customers?)
Key military facilities w/o power	total number of military facilities w/o power (same comment as above)

Source: Petit, F., V. Vargas, J. Kavicky. Grid Modernization: Metrics Analysis (GMLC 1.1) – Resilience. April 2020 https://gmlc.doe.gov/sites/default/files/resources/GMLC1.1_Vol3_Resilience.pdf

Reliability Value-Based Planning accounts for the customer costs of interruptions in planning decisions



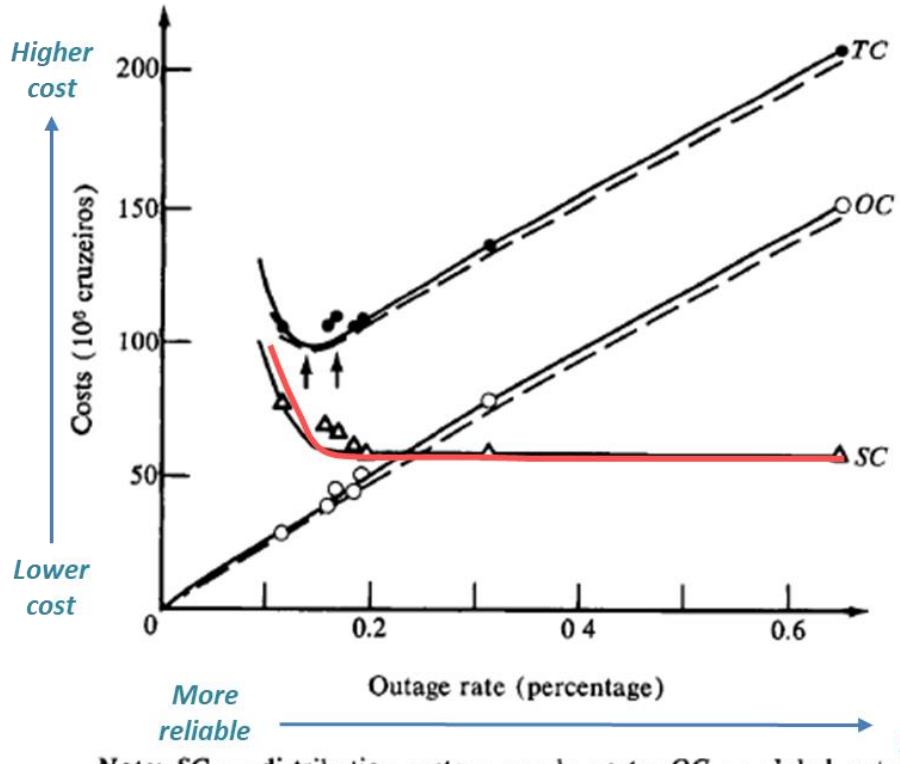
Reliability value-based planning was developed to guide the design of “green field” power systems.

The objective is to minimize the total cost to society of providing reliable electric service.

The societal cost factors include both the cost of building a power system and the costs that unreliability imposes on customers.

Reliability Value-Based Planning accounts for the customer costs of interruptions in planning decisions

Figure 13.1. *Optimization of the Outage System: Costs Versus Outage Rate*



Note: *SC* = distribution system supply costs; *OC* = global outage costs; and *TC* = total costs. The plotted data points and solid lines refer to efficiency priced costs; the broken lines indicate the costs in terms of social prices.

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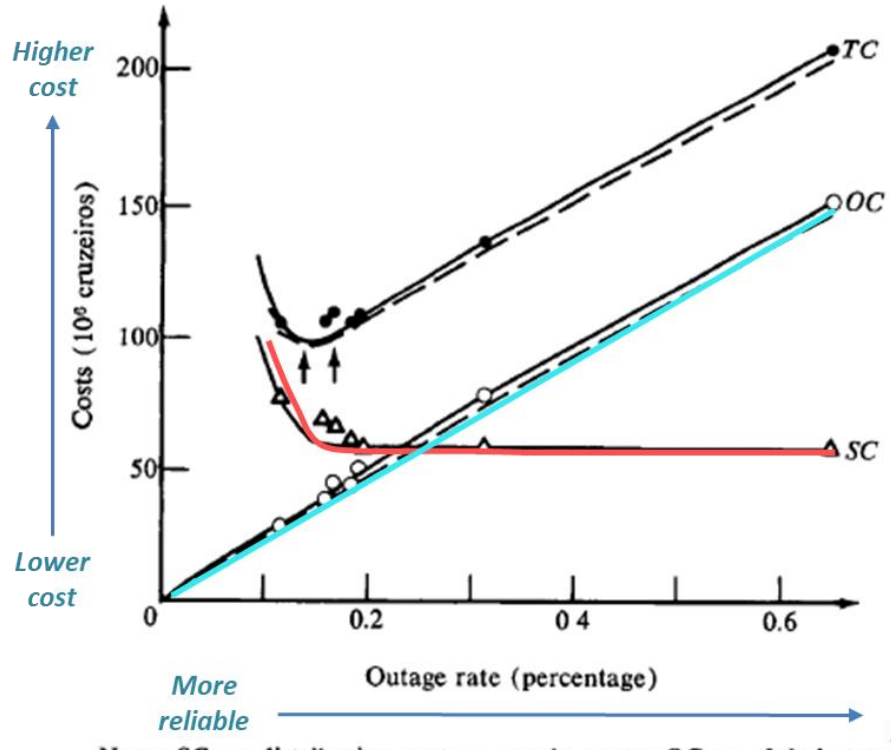

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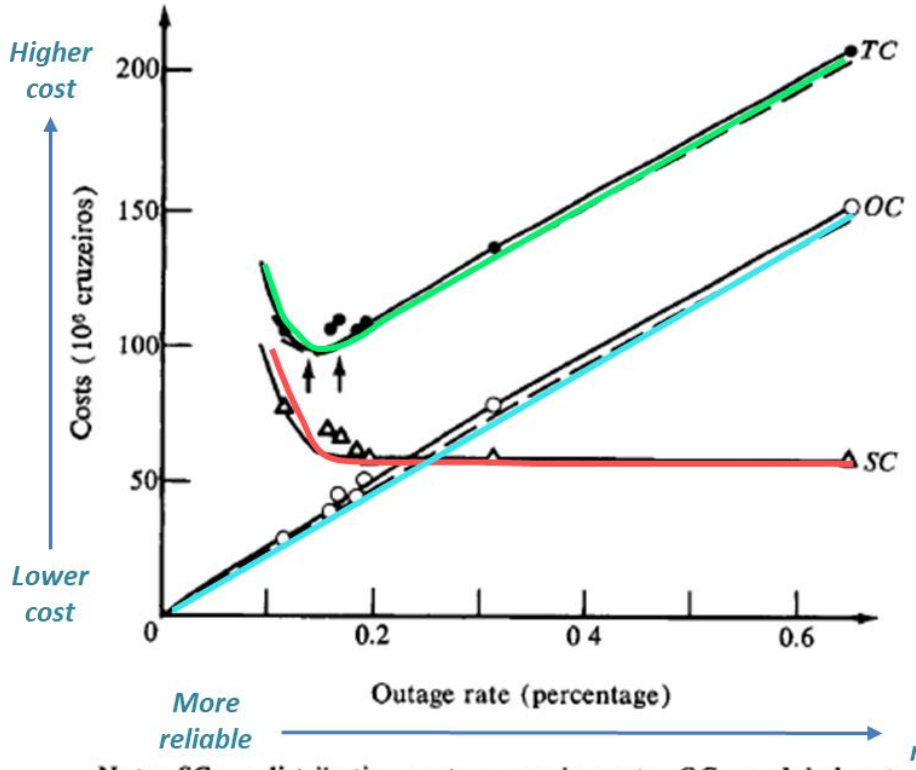

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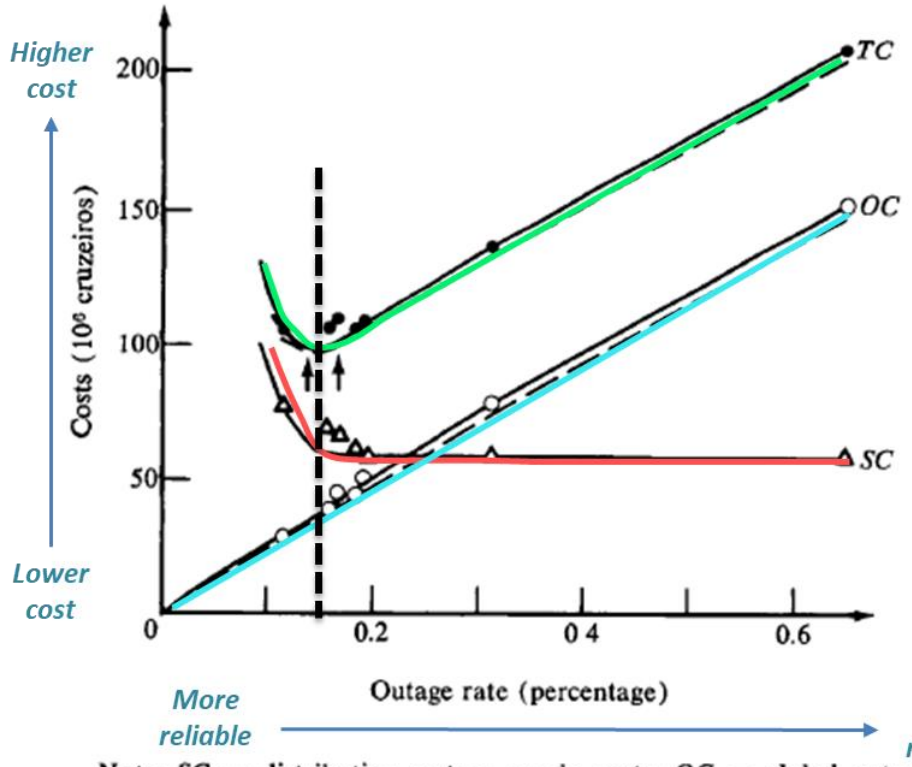

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The Customer Costs of Power Interruptions

Varies by type of customer and depends on when and for how long their lights are out

Interruption Cost	Interruption Duration				
	Momentary	30 minutes	1 hour	4 hours	8 hours
Medium and Large C&I					
Morning	$8,133	$11,035	$14,488	$43,954	$70,190
Afternoon	$11,756	$15,709	$20,360	$59,188	$93,890
Evening	$9,276	$12,844	$17,162	$55,278	$89,145
Small C&I					
Morning	$346	$492	$673	$2,389	$4,348
Afternoon	$439	$610	$818	$2,696	$4,768
Evening	$199	$299	$431	$1,881	$3,734
Residential					
Morning	$3.7	$4.4	$5.2	$9.9	$13.6
Afternoon	$2.7	$3.3	$3.9	$7.8	$10.7
Evening	$2.4	$3.0	$3.7	$8.4	$11.9

LBNL's ICE Calculator was Developed for DOE to Support Reliability Value-Based Planning

- Berkeley Lab's Interruption Cost Estimate (ICE) Calculator is the leading and only publicly-available tool for estimating the customer cost impacts of power interruptions
- ICE Calculator has been used to:
  - provide a basis for discussing utility reliability investments with regulators
  - assess the economic impact of past power outages
  - estimate total costs of power outages for U.S.

http://www.icecalculator.com/

The ICE Calculator is based on 1000s of customer surveys of the costs they incur when the lights go out

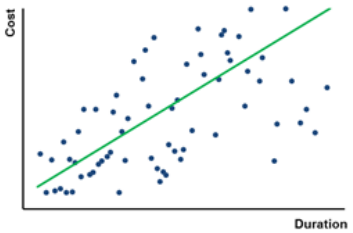
Forecast of Reliability

- SAIFI (frequency)
- SAIDI (mins. interrupted)
- w/ and w/o investment

Customer Survey Meta-database

- 34 surveys
- 10 utilities
- 1989-2012
- N=105,000

Econometric Meta-analysis



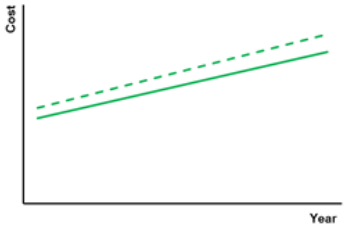
- Med/large C&I
- Small C&I
- Residential
- Other factors

ICE Calculator

Customer Characteristics

- Customer class
- Usage (kWh)
- Industry

Forecast of Customer Outage Costs



- ICE Calculator output
- w/ and w/o investment

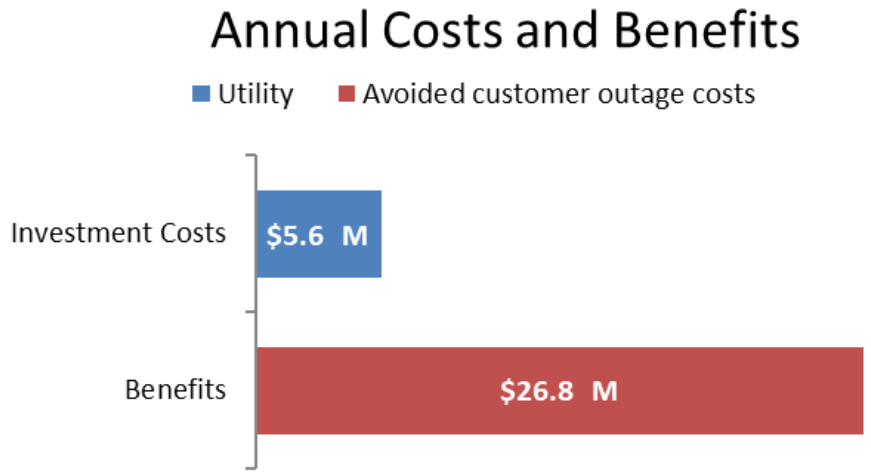
Updated analysis with new surveys and model coefficients in early 2015 - http://eetd.lbl.gov/sites/all/files/lbnl-6941e_0.pdf (new report)

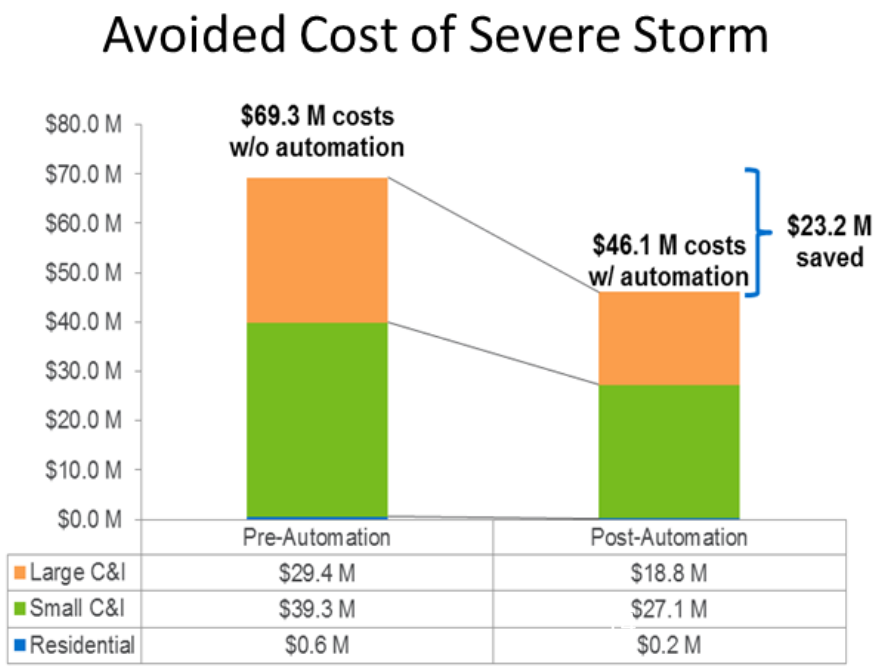
Reliability Value-Based Planning example: Distribution Automation

- Utility: EPB of Chattanooga
- Investment: 1,200 automated circuit switches and sensors on 171 circuits
- Reliability Improvement (between 2010 and 2015):
  - SAIDI ↓45%

    (from 112 to 61.8 minutes/year)
  - SAIFI ↓51%

    (from 1.42 to 0.69 interruptions/year)





Motivation for National Initiative to Upgrade the ICE Calculator

- Currently, the utility survey-based information relied on by the ICE Calculator is:
  - Dated—some of the surveys are 20+ years old
  - Not statistically-representative for all regions of the U.S.
  - Not appropriate for estimating costs of widespread, long-duration (> 24 hour) interruptions
- With encouragement and support from DOE and the Edison Electric Institute (EEI), Berkeley Lab now seeks to support upgrades to the ICE Calculator through direct funding by sponsoring U.S. utilities.

Utility Company	Survey Year	Number of Observations			Min. Duration (Hours)	Max. Duration (hours)
		Medium and Large C&I	Small C&I	Residential		
Southeast-1	1997	90			0	1
Southeast-2	1993	3,926	1,559	3,107	0	4
	1997	3,055	2,787	3,608	0	12
Southeast-3	1990	2,095	765		0.5	4
	2011	7,941	2,480	3,969	1	8
Midwest-1	2002	3,171			0	8
Midwest-2	1996	1,956	206		0	4
West-1	2000	2,379	3,236	3,137	1	8
West-2	1989	2,025	5		0	4
	1993	1,790	825	2,005	0	4
	2005	3,052	3,223	4,257	0	8
	2012	5,342	4,632	4,106	0	24
Southwest	2000	3,991	2,247	3,598	0	4
Northwest-1	1989	2,210		2,126	0.25	8
Northwest-2	1999	7,091		4,299	0	12

National Initiative to Upgrade the ICE Calculator

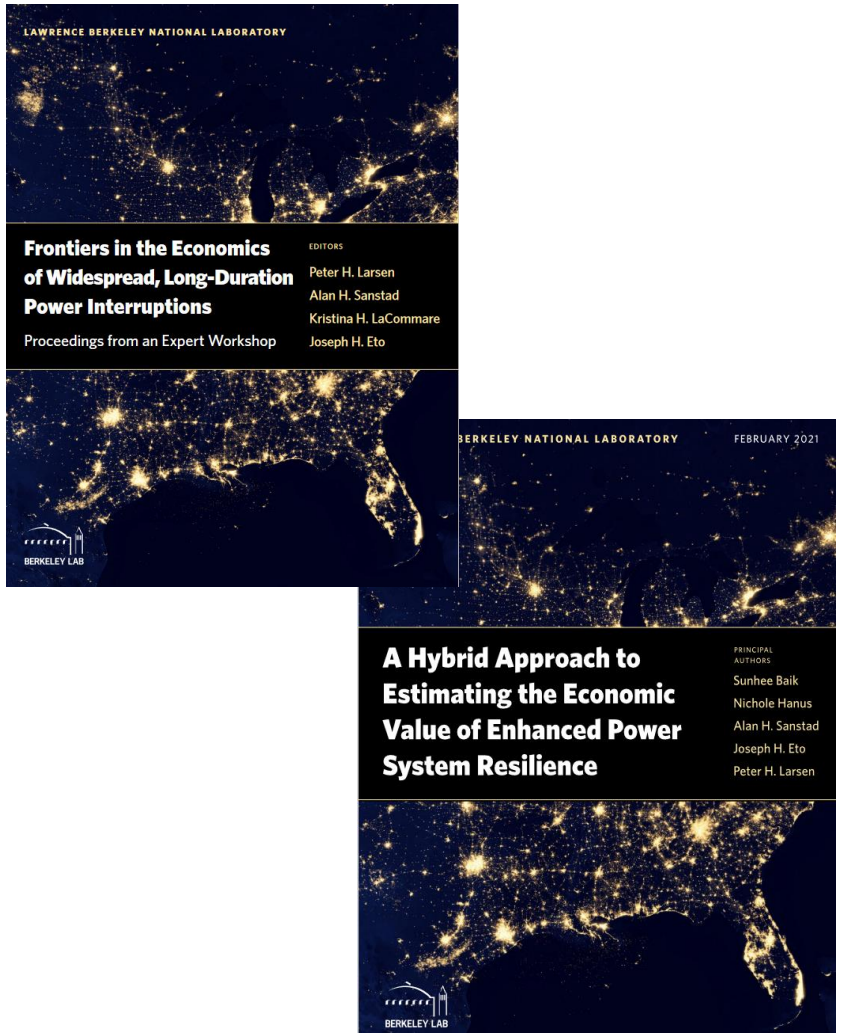
Berkeley Lab, Edison Electric Institute (EEI), and sponsoring utilities are collaborating to:

1. Develop a consistent set of short duration, customer interruption cost (CIC) survey questions, including supplemental questions to understand customer behavior during widespread, longer duration interruptions
2. Coordinate administration of CIC surveys to ensure survey results, collectively, will be statistically representative for all U.S. regions and customer classes
3. Update ICE Calculator with new CIC information as well as other suggested improvements to its design/performance

Organization	Roles and Responsibilities
Berkeley Lab + subcontractors	• Develop survey instrument and survey administration protocols • Conduct pre-testing and administer survey • Process CIC survey data • Upgrade ICE Calculator with new CIC information and incorporate additional feedback
EEI	• Support coordination of participation by utilities
Sponsoring utilities	• Provide funding • Support survey administration and sampling of customers • Provide additional feedback on ICE Calculator improvements to Berkeley Lab

Estimating the Economic Impacts of Widespread, Long Duration (WLD) Power Interruptions

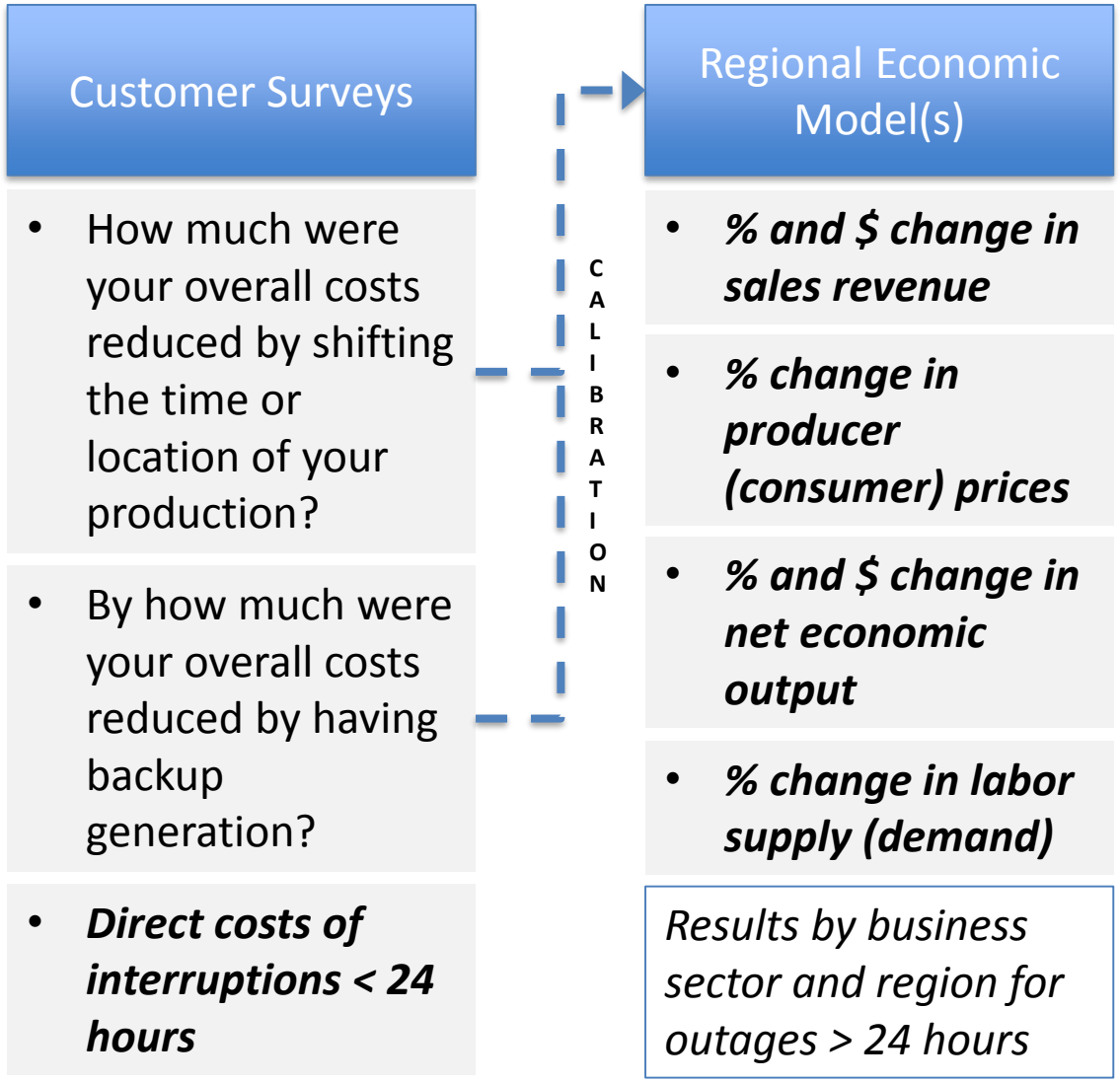
- Survey-based approaches are not well-suited for developing information on the customer cost of WLD power interruptions
  - Customers are challenged to estimate costs for WLD power interruptions
  - Customers cannot estimate indirect costs of WLD power interruptions
- Regional economic models (REM), which can estimate direct and indirect costs of WLD power interruptions, are unfamiliar to utilities and their regulators
  - REMs are well-established in the academic literature
  - REMs require extensive calibration to provide insight into real-world events
- LBNL has developed and is now demonstrating a hybrid approach that combines surveys with REM



LBNL has Developed a Hybrid Approach to Estimate the Economic Impacts of WLD Power Interruptions

- Step 1: Conduct surveys to identify mitigating/adaptive behaviors that residential, commercial, industrial, and public sector customers can take to reduce risk before, during, or after a power interruption occurs

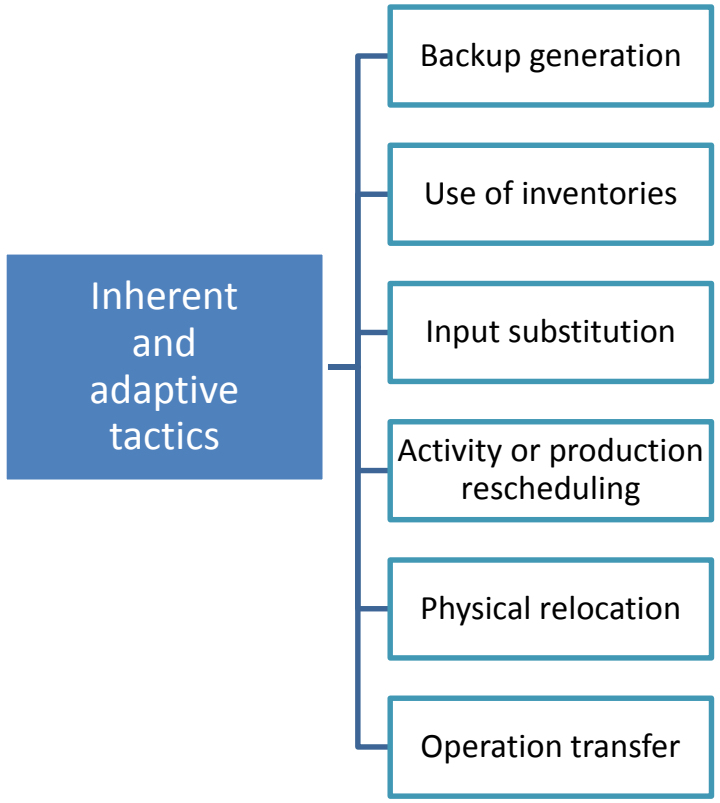
- Step 2: Use the survey responses to calibrate regional economic models to assess the full range of economic impacts from power interruptions

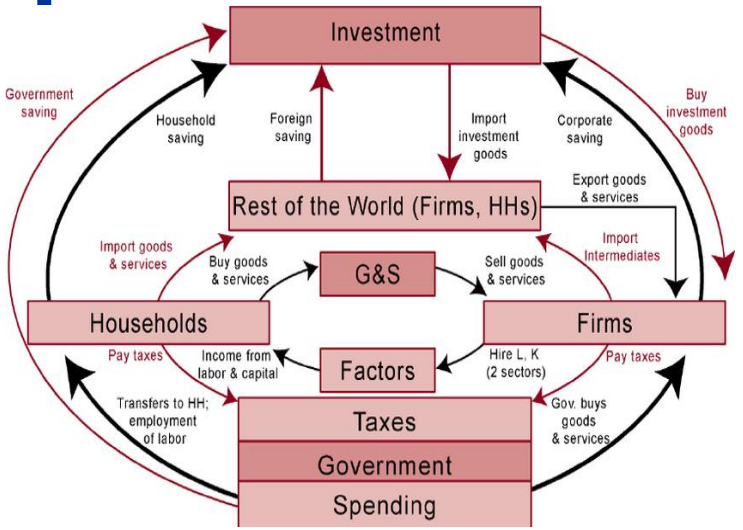


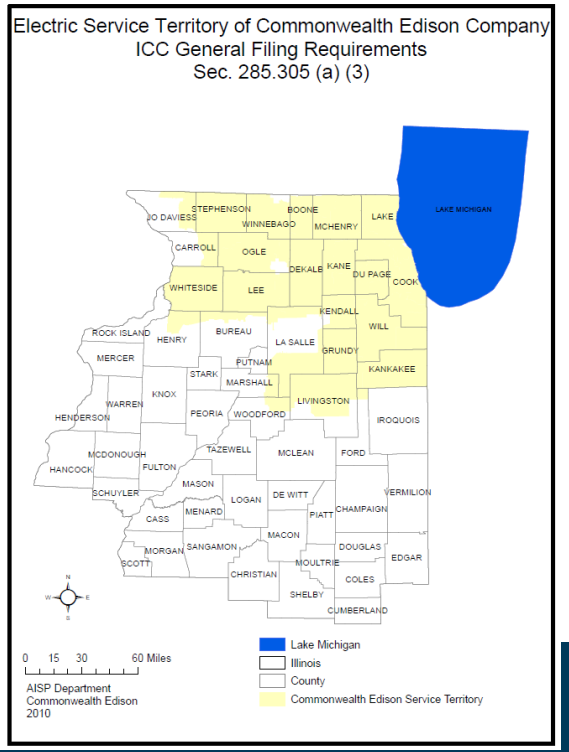
LBNL is Demonstrating the Hybrid Approach with Commonwealth Edison

- We are collaborating with Commonwealth Edison (ComED) to conduct a field demonstration of the hybrid approach

- During the field demonstration, we will explore some critical issues (e.g., complexity of regional economic models and their data intensity, the costs of survey design and implementation, differences in results between direct elicitation and model output)



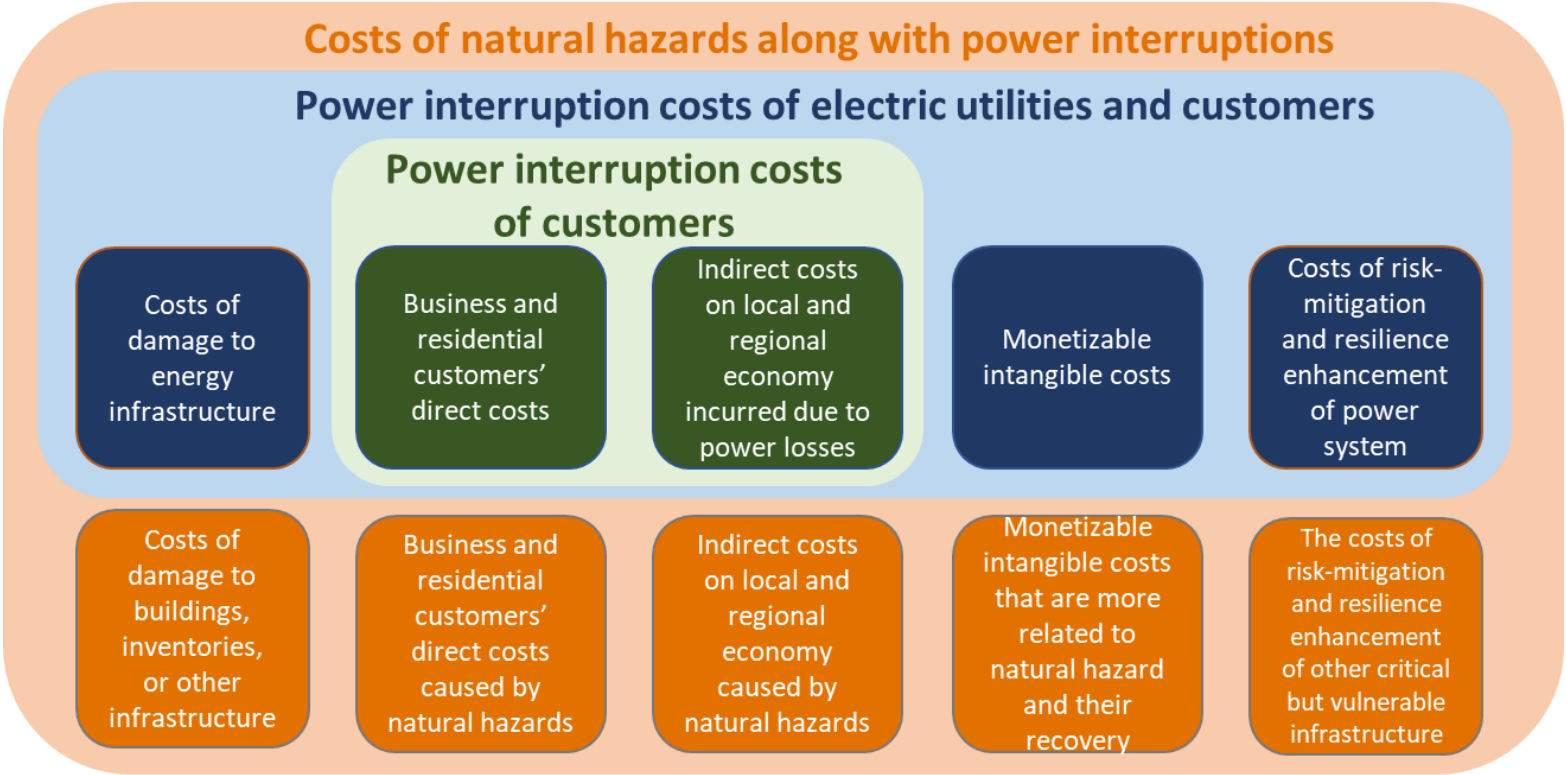




ComEd
An Exelon Company

Customer Costs of Power Interruptions: necessary, but not sufficient

- The POET approach focusses on estimating the direct and indirect economic consequences of widespread, long-duration power interruptions
- While of great importance, they are not the only costs that should be considered in resilience decision making



Thank you

Joe Eto

jheto@lbl.gov

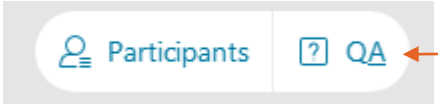
LBNL publications on reliability and resilience are available at:

https://emp.lbl.gov/research/electricity-reliability

Discussion and Q&A

WebEx Tip

Option 1:



Access the written Q&A panel here

Option 2:

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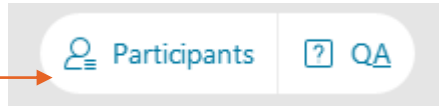

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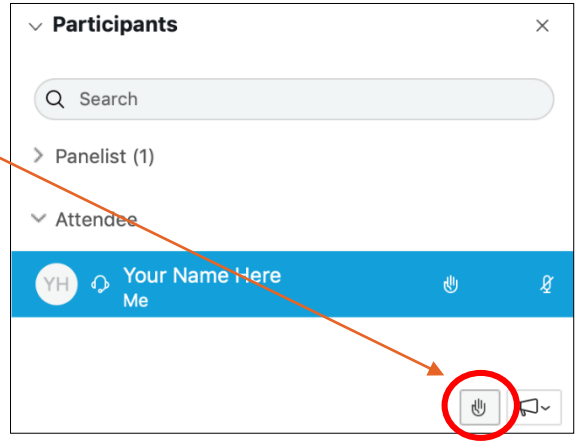

Upcoming Meetings

- **Wednesday, May 19, 2021, 2-4PM**
  Topic: Value of Resiliency – Pillar I: Baseline Assessment; additional presentations TBD
- **Thursday, June 3, 2021, 2-4PM**
  Topic: Value of Resiliency – Pillar 2: Mitigation Measure Assessment (discussion); Sandia Labs presentation of transmission and distribution resiliency and reliability modeling tools
- **Thursday, June 17, 2021, 2-4PM**
  Topic: Value of Resiliency – Pillar 3: Resiliency Scorecard; additional presentations TBD

For more information:

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Phone: (415) 703-2845
https://www.cpuc.ca.gov/resiliencyandmicrogrids/