# Valuing Power System Resilience: *In Policy and Practice*

Presentation to Electricity Advisory Committee

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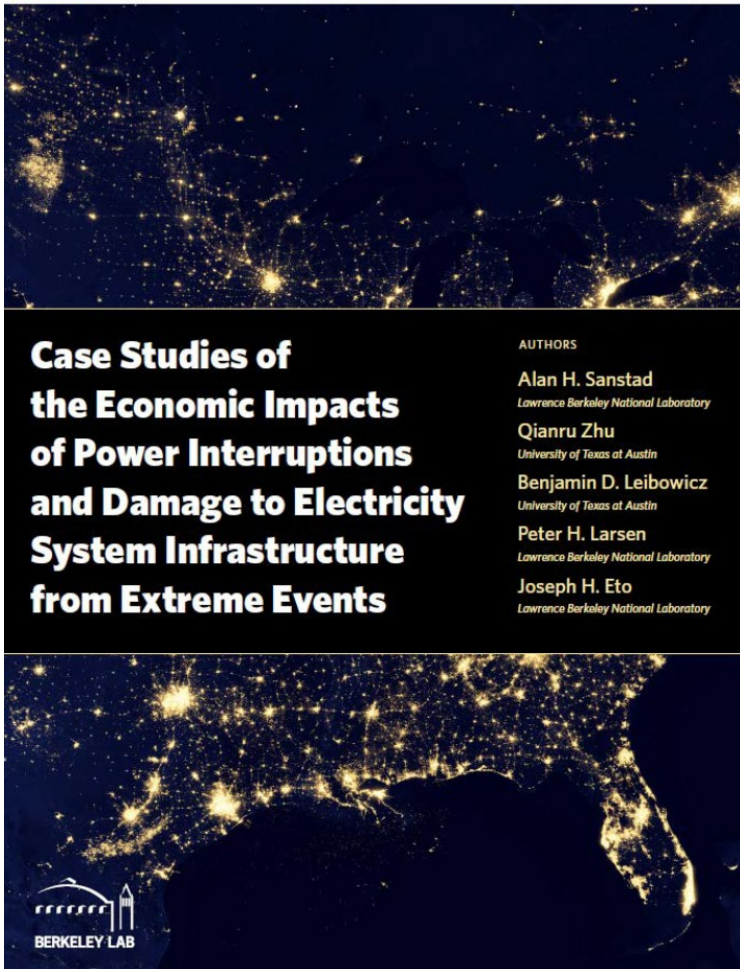
# My Comments Today…

- Focus is on how economic metrics are used by utilities and policymakers to:

1. recover from past natural hazards

2. plan for future natural hazards



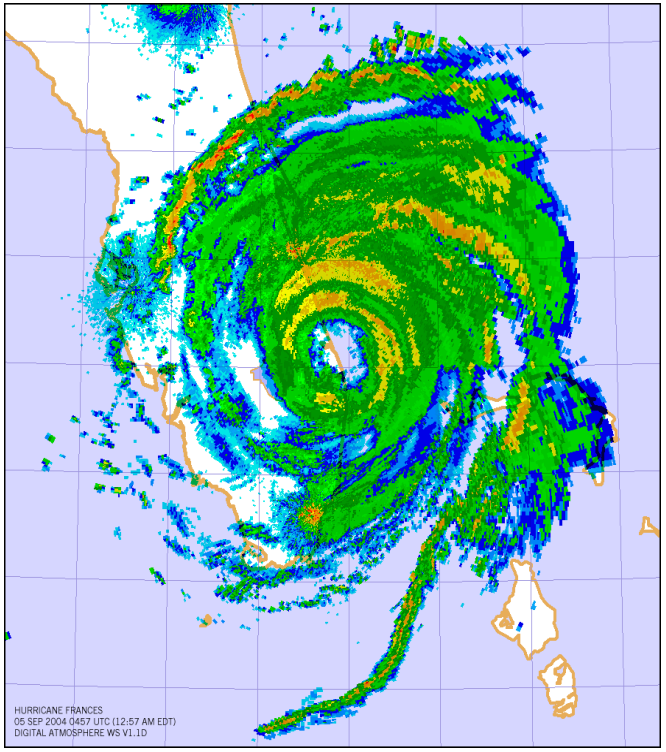
# Motivation

- *Long-duration, widespread power interruptions* (LDWIs) are those lasting days, weeks or longer, and affecting entire utility service territories or larger regions—often caused by extreme weather.

- There is a growing need on the part of utilities and policymakers for information on the:

1. Economic impacts of LDWIs

2. Costs and benefits of investments to mitigate such impacts



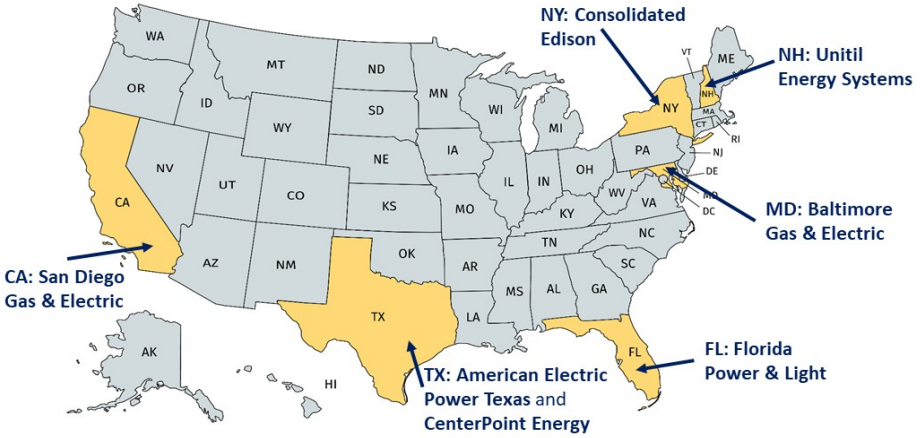
# Motivating Questions

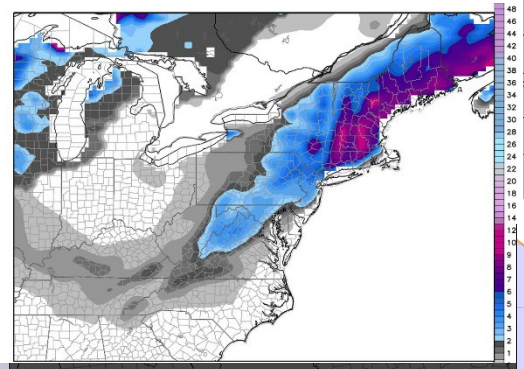
- *How do utilities…*
  1. *Assess the costs of system damage caused by extreme weather and the costs of recovering from this damage?*
  2. *Estimate customer costs of past power interruptions?*
  3. *Estimate the costs and benefits of investments to reduce power system vulnerabilities to future extreme weather events?*
  4. *Use the concept of "resilience" when making economic assessments of extreme weather impacts and the value of preventive investments?*

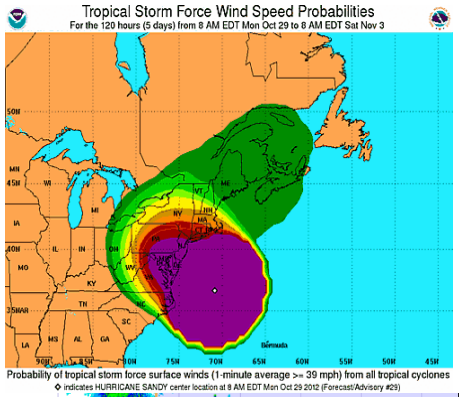
- *How do regulatory processes influence utilities' economic analyses related to power interruptions?*

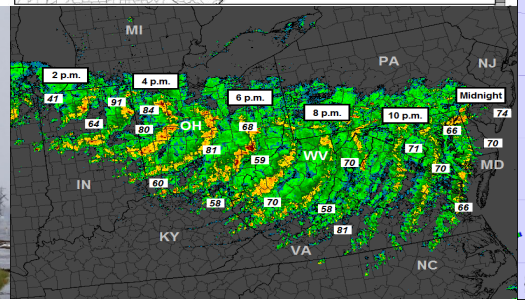
# Approach and Scope

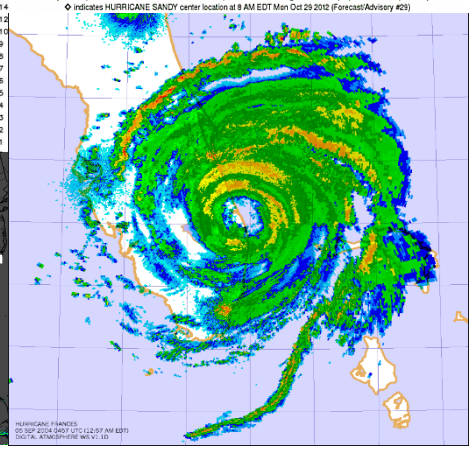
- We conducted case studies of investor-owned utilities and regulatory processes in six jurisdictions—selected for geographic, regulatory, utility-practice, and extreme event-type variation.





# Research Method

| Jurisdiction | Precipitating event |
|---|---|
| Florida | Hurricanes of 2004-2005 |
| New York | Tropical Storm Sandy, 2012 |
| Texas | Hurricanes of 2005, 2008, 2017 |
| California | 2007 Southern California wildfires |
| New Hampshire | Severe fall and winter storms in 2008, 2011, and 2014 |
| Maryland | Derecho (severe wind event) in 2012 |

- Primary source of information was state public utilities commissions' online regulatory archives
- Secondary sources included reports by other state government agencies and academic literature

# Research Method (cont.)

| Availability of information on categories of economic impacts summarized in tables… | |
|---|---|
| Symbol | Key |
| ● | Extensive publicly-available documentation |
| ◒ | Moderate amount of publicly-available documentation |
| ○ | Little/no publicly-available documentation |

- Economic information related to ***cost recovery*** including:

1. Transmission system costs
2. Distribution system costs
3. Generation system costs
4. Increased customer service costs
5. Other costs

- Economic information related to ***mitigating future impacts*** including:

1. Avoided customer interruption costs
2. Avoided regional economic impacts
3. Other avoided societal impacts
4. Other
5. Cost-effectiveness or cost-benefit analysis conducted?

# Summary of Available Information: *Cost Recovery*

| Availability of economic information related to cost recovery… | | | | | | |
|---|---|---|---|---|---|---|
| **Utility** | **Precipitating Event** | **Trans. System Costs** | **Dist. System Costs** | **Gen. System Costs** | **Increased Customer Service Costs** | **Other Costs** |
| Florida Power & Light (FL) | Hurricanes of 2004-2005 | ● | ● | ● | ● | ● |
| Consolidated Edison (NY) | Tropical Storm Sandy | ● | ● | ● | ● | ● |
| AEP Texas (TX) | Hurricanes of 2005, 2008, and 2017 | ● | ● | N/A | ◒ | ● |
| San Diego Gas and Electric (CA) | 2007 Southern California wildfires | ○ | ○ | ○ | ○ | ○ |
| Unitil Energy Systems (NH) | Severe fall and winter storms | N/A | ● | N/A | ○ | ○ |
| Baltimore Gas & Electric (MD) | June 2012 Derecho | ● | ● | ● | ○ | ○ |

# Summary of Available Information: *Mitigating Future Impacts*

| Availability of economic information related to mitigating future customer and regional impacts… | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Organization** | **Precipitating Event** | **Avoided Customer Interruption Costs** | **Avoided Regional Economic Impacts** | **Other Avoided Societal Impacts** | **Other** | **Cost-Effectiveness Analysis?** | **Cost-Benefit Analysis?** |
| Florida Power & Light (FL) | Hurricanes of 2004-2005 | ○ | ○ | ○ | ○ | Yes | No |
| Consolidated Edison (NY) | Tropical Storm Sandy | ● | ○ | ○ | ○ | Yes | Yes |
| City of New York (NY) | Tropical Storm Sandy | ○ | ◒ | ○ | ○ | Yes | Yes |
| CenterPoint Energy (TX) | Hurricanes of 2005, 2008, and 2017 | ◒ | ○ | ○ | ○ | Yes | Yes |
| San Diego Gas and Electric (CA) | 2007 Southern California wildfires | ◒ | ○ | ○ | ○ | Yes | No |
| Unitil Energy Systems (NH) | Severe fall and winter storms | ○ | ○ | ○ | ○ | Yes | No |
| Grid Resiliency Task Force (MD) | June 2012 Derecho | ● | ○ | ○ | ○ | Yes | Yes |

# Summary of Key Findings

- ***How do utilities assess the costs of system damage caused by extreme weather and the costs of recovering from this damage?***
  - Utilities conduct detailed physical and engineering assessments of damages
  - They estimate costs of replacement and repair as well as response and recovery operations

- ***How do utilities estimate customer costs of past power interruptions?***
  - Utilities often report statistics, including the counts, locations, and durations of customers without power, but generally did not monetize these customer impacts

- ***How do utilities or others estimate the costs and benefits of investments to reduce power system vulnerabilities to future extreme weather events?***
  - Costs of preventive investments can be estimated with reasonable accuracy, but the economic benefits are very uncertain
  - Cost-effectiveness analysis is the most common method
  - Berkeley Lab's ICE Calculator was used, but there was no evidence of avoided cost information being developed specifically for LDWI applications
  - No utility or regulator used regional economic modeling to estimate either direct or indirect costs of power interruptions

# Summary of Key Findings (cont.)

- ***How do utilities and regulators use the concept of resilience in economic assessments of extreme weather impacts and the value of preventive investments?***
  - Utilities and regulators referred to "resilience" extensively in two of the case studies, a moderate amount in two others, and very little in the remaining two
  - "Resilience investments" were typically related to traditional storm hardening, for example, but at greater scale and cost
  - The challenge is not what "resilience metrics" should be used, but rather how to value proposed investments using these metrics within a cost-benefit framework
- ***How do regulatory processes influence utilities' economic analysis related to power interruptions?***
  - Laws, regulations, and regulatory practices can significantly influence utilities' preparation for, and response to, long-duration widespread power interruptions
  - New economic tools and methods are usually developed and/or adopted through collective decision-making involving utilities as well as other stakeholders, rather than unilaterally by utilities

# ELECTRICITY MARKETS & POLICY

**Preceding report can be downloaded by visiting:**

**https://emp.lbl.gov/**

**For more information, please contact:**

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# A Few Real-world Examples of Estimating Economic Impacts of Power Interruptions...

# #1: Power Outage Economics Tool (POET)

- Conducting *hybrid* resilience valuation approach that integrates:
  1. Survey-based techniques to identify mitigating/adaptive behaviors that residential, commercial, industrial, and public sector customers may take to reduce risk before, during, or after a power interruption occurs
  2. Regional economic models that have been calibrated—using survey responses—to assess the full range of economic impacts from power interruptions
- Allow users to estimate direct and indirect impacts of power interruptions under a wide range of scenarios

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| Customer Surveys | | Regional Economic Model(s) |
|---|---|---|
| • How much were your overall costs reduced by shifting the time or location of your production? | CALIBRATION | • ***% and $ change in sales revenue*** |
| | | • ***% change in producer (consumer) prices*** |
| • By how much were your overall costs reduced by having backup generation? | | • ***% and $ change in net economic output*** |
| | | • ***% change in labor supply (demand)*** |
| • ***Direct costs of interruptions < 24 hours*** | | *Results by business sector and region for outages > 24 hours* |

# #2: FRONTIER and LVAT-RADIANCE

- DOE ETI-funded *FRONTIER* project allows decision-makers, including local planners, asset owners and operators, and emergency management officials, to evaluate resilience value for utilities that are either physically or functionally isolated from neighboring communities and systems.


- DOE GMLC-funded LVAT project estimating the costs and benefits of six resilient distribution systems, including the RADIANCE project in Cordova, Alaska
  - Hybrid valuation technique to be employed (surveys + regional economic modeling)

# #3: Interruption Cost Estimate (ICE) Calculator

- Berkeley Lab's ICE Calculator is the leading tool for estimating the customer cost impacts of power interruptions and had been used to:
  - provide a basis for discussing utility investments with regulators
  - assess the economic impact of past power outages
  - estimate total costs of power outages for entire U.S.


- 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…

# Seeking Support for ICE Calculator 2.0 Initiative

- U.S. Department of Energy (DOE) has supported the development and public availability of the ICE Calculator.

- With encouragement 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***.

**Please contact me if you are interested in connecting us with utilities and/or regulators who may be willing to support the ICE Calculator 2.0 initiative:**

**PHLarsen@lbl.gov**