

The National Cost of Power Interruptions to Electricity Customers – *A Revised Update*

Distribution Reliability Working Group
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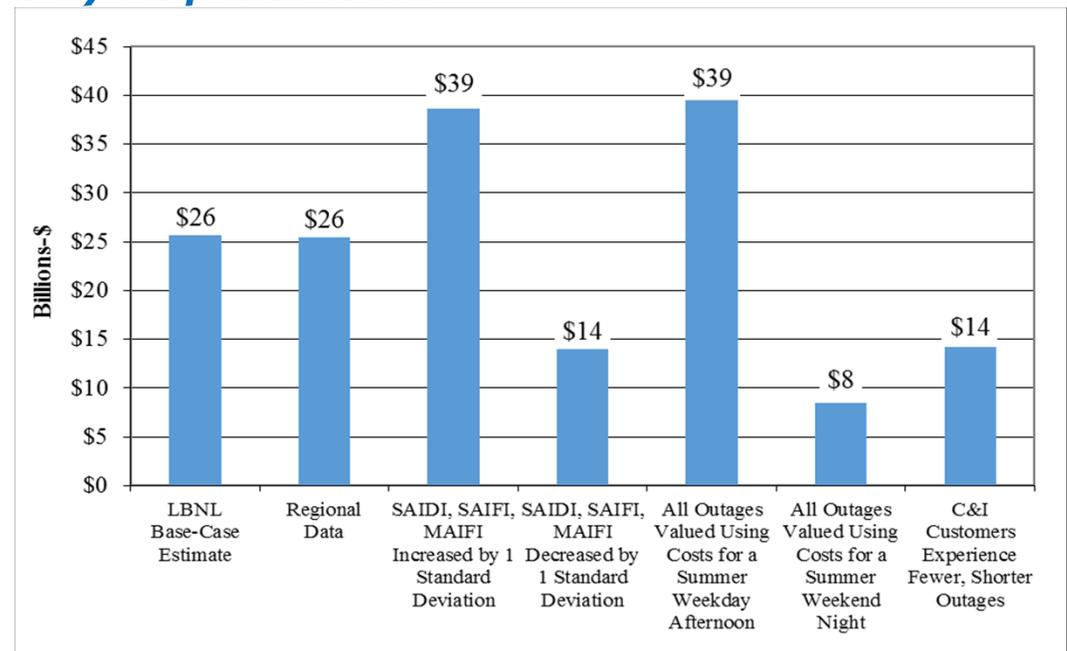
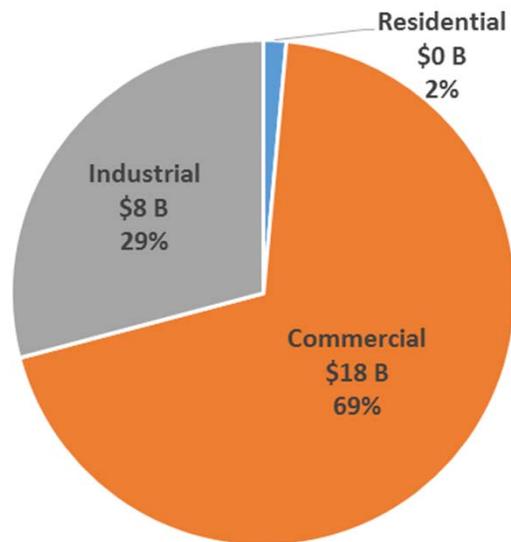
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Overview/Background

- In 2004, LBNL published the first peer-reviewed assessment of the national cost of power interruptions to electricity customers based entirely on publicly available data
 - Found that data were sparse, poorly understood, and often misinterpreted
- Since that time, LBNL has worked closely with industry, regulators, and federal government to improve understanding, quality, and public availability of information on electricity reliability
 - Actively participated in IEEE DRWG to better understand industry perspectives and research aspects of Standard 1366
 - Developed and promoted use of the Interruption Cost Estimate (ICE) Calculator
 - Reviewed OE-417 and NERC EOP-004
 - Supported modifications to EIA form 861
 - Provided regular, invited briefings to NARUC Electricity and Electricity Reliability Staff Subcommittees
- This presentation is an revised preview of LBNL's update to its 2004 study

In 2004, LBNL estimated that sustained power interruptions cost the US \$26 billion/year (2002-\$)

LBNL's research was the first and remains the only peer-reviewed analysis based entirely on public data



LBNL also documented significant uncertainties in its analysis, ranging from \$8-39 billion

Sources: Hamachi LaCommare, K. and J. Eto. 2006. "Cost of Power Interruptions to Electricity Consumers in the United States." *Energy, the International Journal*. 31:1509-1519. LaCommare, Kristina H., and J. H. Eto. 2004. Understanding the Cost of Power Interruptions to U.S. Electricity Consumers. LBNL-55718. Accessible at: <https://emp.lbl.gov/sites/all/files/REPORT%20lbnl%20-%2055718.pdf>.

A Customer-Focused Framework for Estimating the National Cost of Power Interruptions

$$\text{Cost of Power Interruptions} = \sum_{i=1}^m \sum_{j=1}^n C_{i,j} \times E_{i,j} \times O_{i,j} \times V_{i,j}$$

where,

C = total number of electric power customers in each region and customer class sector

E = the frequency of power interruption events in one year for each region and customer class sector

O = the cost per interruption as a function of outage duration by customer class for each region

V = vulnerability factor

m = the number of customers in each customer class

n = the number of regions

i,j = indices for customer class and region, respectively

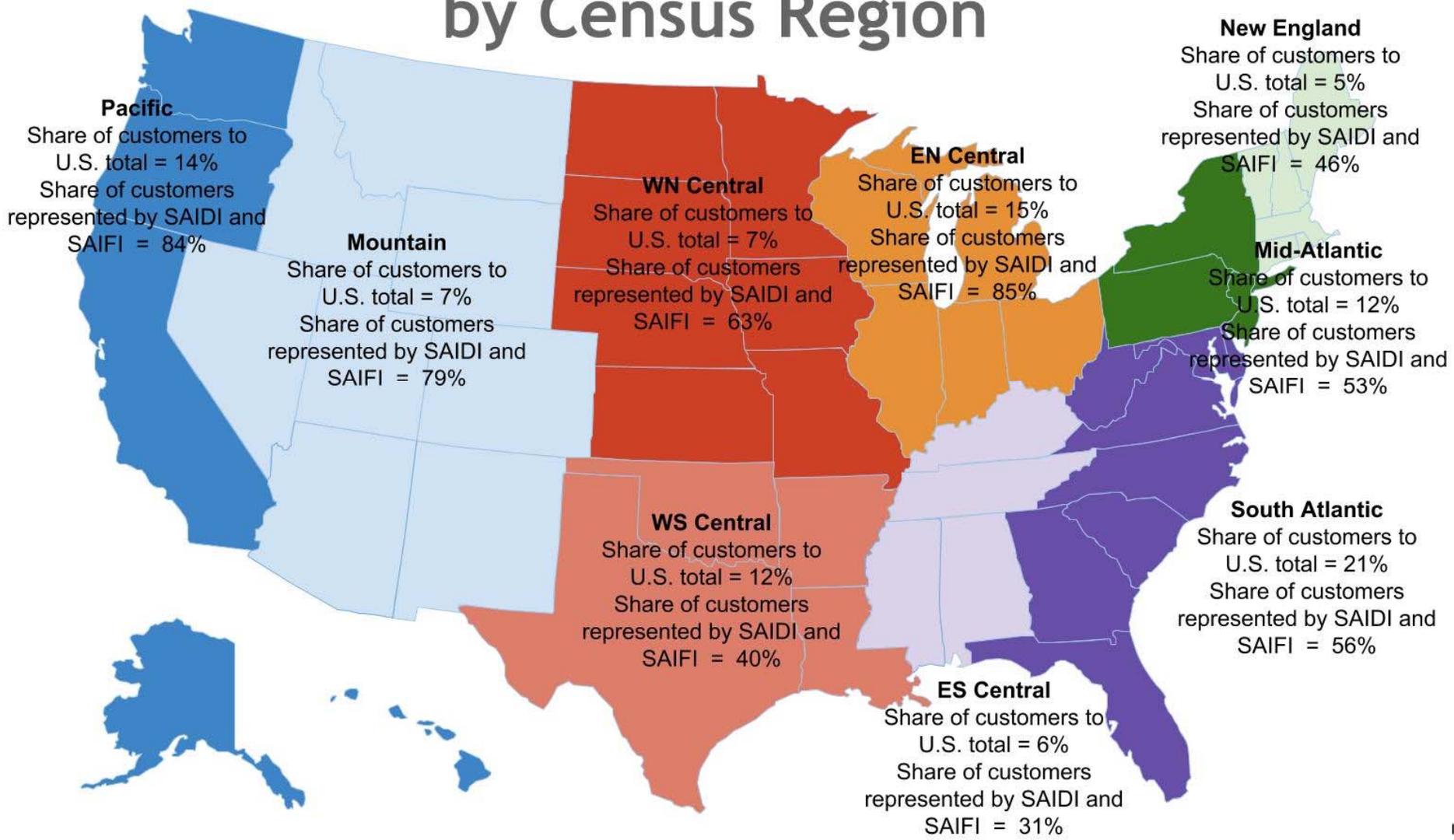
Customer Count by Class (C)

What we used for the 2004 study	What we've used for the current study	What we would like to use for the next study
<p>Year 2001 customer counts by class using EIA 861</p>	<p>Year 2015 customer counts by class using EIA 861</p> <p>Note: In 2003, EIA changed its definition of the 'Other' category, which led to a shift the customer count to the commercial from the industrial sector</p>	<p>Better alignment between EIA definitions (C and I) and those used in the surveys that were used to build the ICE Calculator (small/med C&I and large C&I)</p> <p><i>OR</i></p> <p>A revised ICE Calculator based on a new national interruption cost survey developed based on EIA customer class definitions</p>

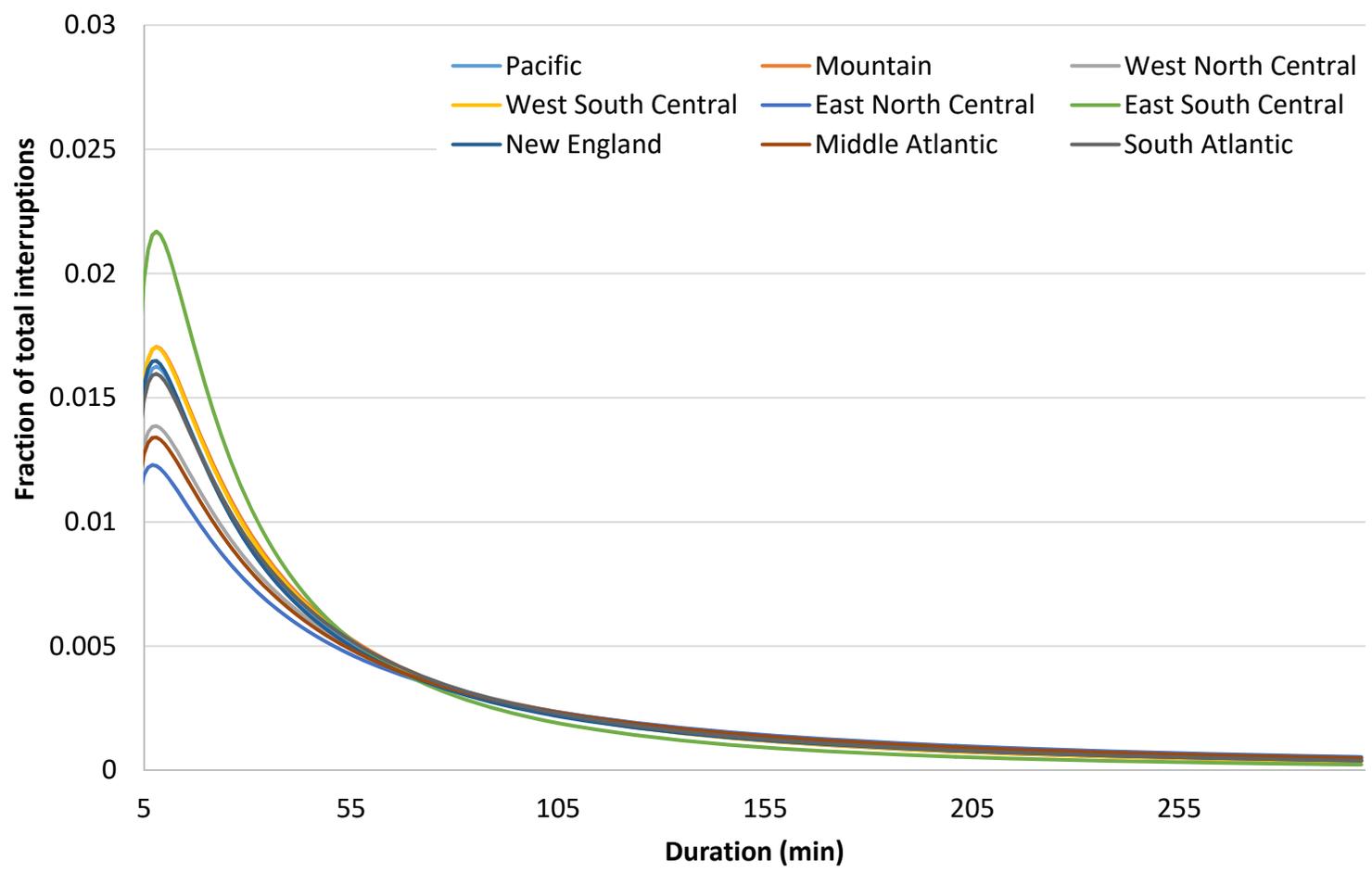
Frequency and Duration of Interruptions(E)

What we used for the 2004 study	What we've used for the current study	What we would like to use for the next study
<p>A convenience sample of readily available public data on SAIDI and SAIFI (with major events) and MAIFI averaged over the entire U.S.</p>	<p>2013-2015 SAIDI and SAIFI (with major events) collected by EIA from hundreds of utilities weighted and averaged separately for each of the nine U.S. Census regions</p> <p>SAIDI converted into distributions of event durations using data collected from utility websites</p> <p>No estimate of cost of momentary interruptions</p>	<p>A statistically representative, yet enhanced SAIDI and SAIFI-like metric that distinguishes among customers by type</p> <p>AND</p> <p>Metrics that provides for a more explicit representation of the duration of interruptions experienced by customers</p>

Representation of SAIDI and SAIFI by Census Region



Re-expressing SAIDI as a Distribution of Outage Durations



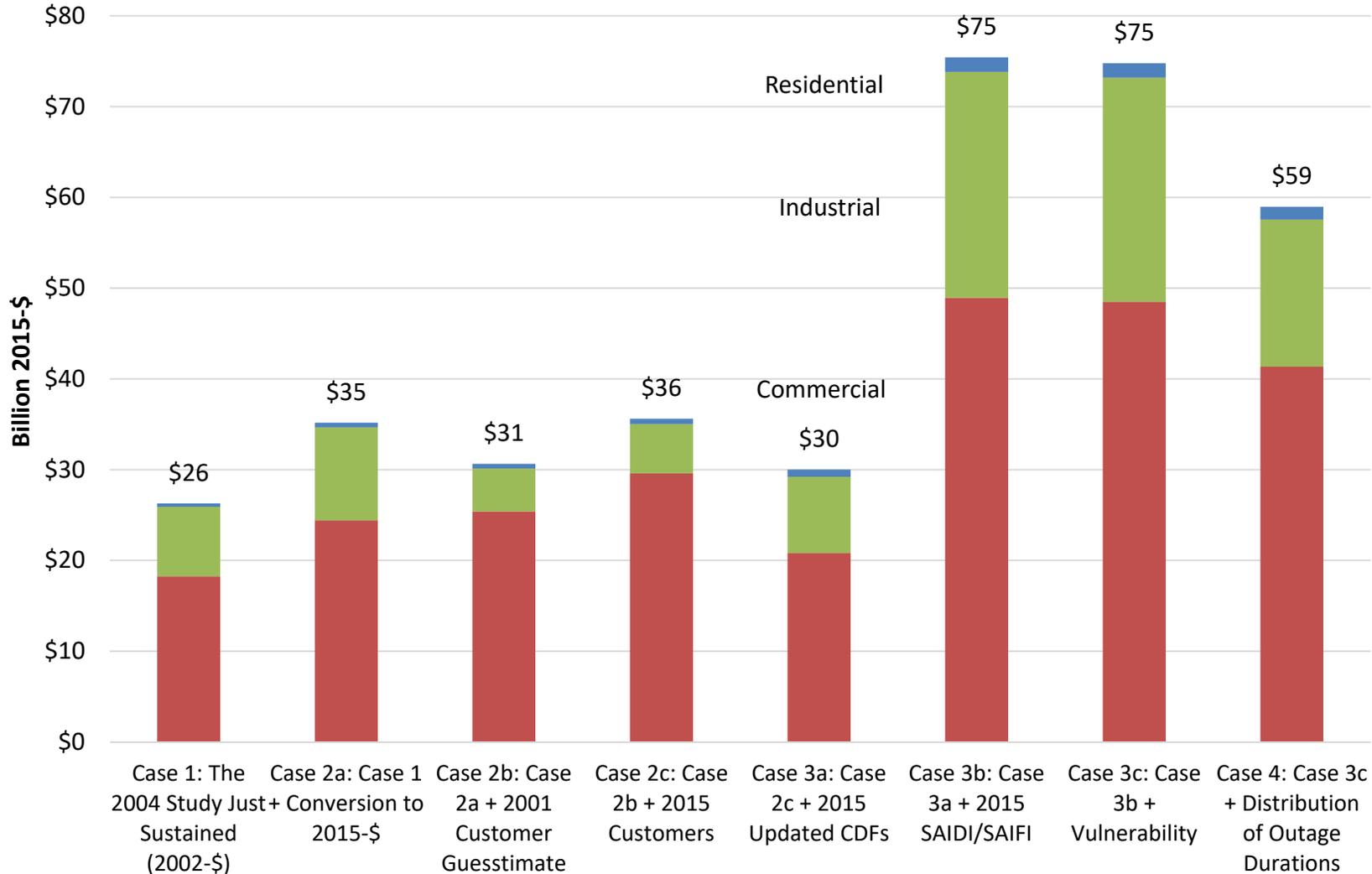
Economic Cost of Interruptions (O)

What we used for the 2004 study	What we've used for the current study	What we would like to use for the next study
<p>A meta-analysis that developed customer damage functions (CDFs) based on 24 utility customer surveys administered by 8 utilities between years 1989-2002</p>	<p>An updated meta-analysis that developed new CDFs based on 34 utility customer surveys administered by 10 utilities between 1989-2012</p> <p>The CDFs are based on a more advanced, two-part regression model (= the current ICE Calculator)</p>	<p>A new, statistically representative national survey of customer interruption costs that supports regional variations</p> <p>Augmented by a separate analysis of the cost of long-duration, widespread power interruptions</p>

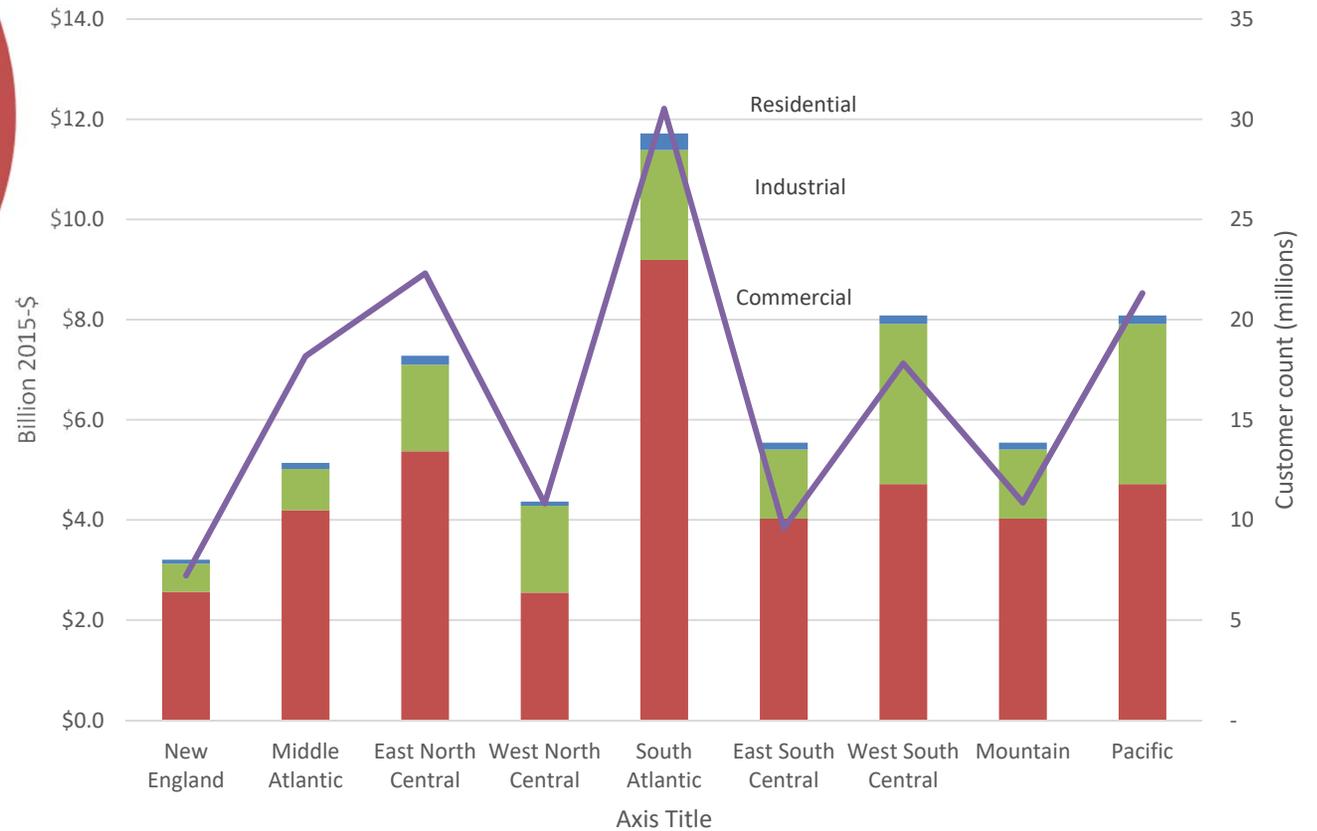
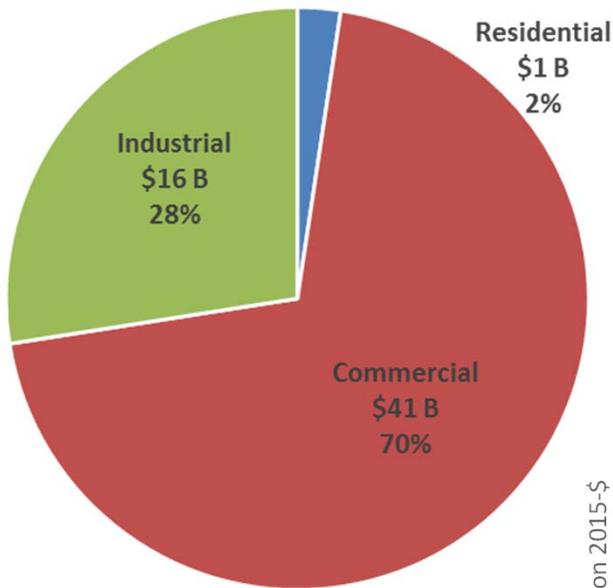
Vulnerability (V)

What we used for the 2004 study	What we've used for the current study	What we would like to use for the next study
<p>In the absence of any data, we assumed all customers were vulnerable to power interruptions</p>	<p>We commissioned a study by Frost & Sullivan (2015) to develop regional market penetration estimates of stand-by generators and UPS systems by customer class</p>	<p>Updated and more granular information on stand-by generators and UPS</p> <p>Augmented by better understanding of the resilience of modern electricity consuming equipment</p>

U.S. cost of sustained power interruptions, by step-by-step case and sector, in billion 2015-\$

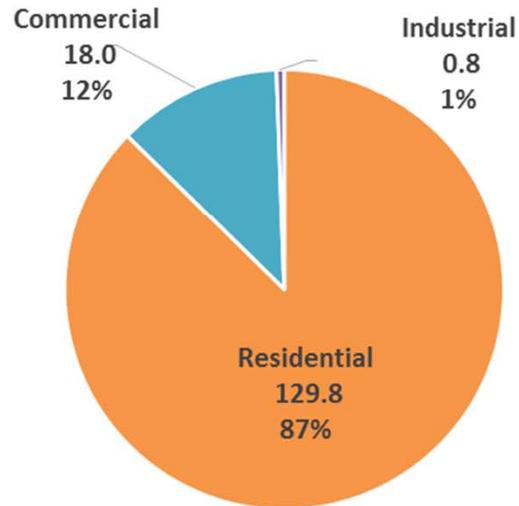


National Cost of Sustained Power Interruptions \$59 billion (2015-\$)

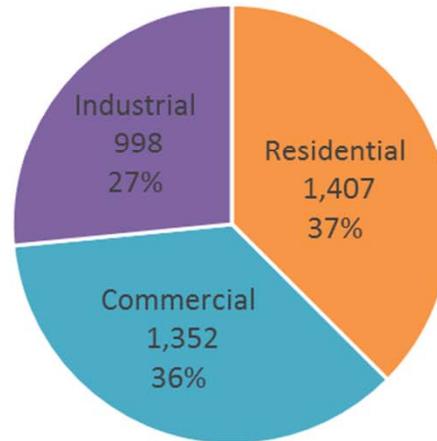


A Look Behind the Numbers

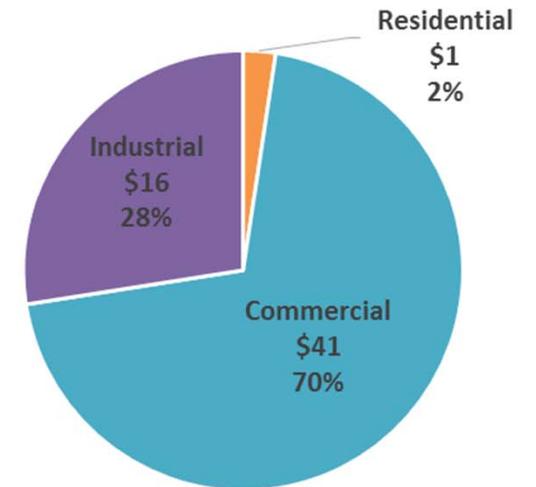
Customer Count (millions)



Electricity Sales (TWh)



Updated US COPI (billion 2015-\$)

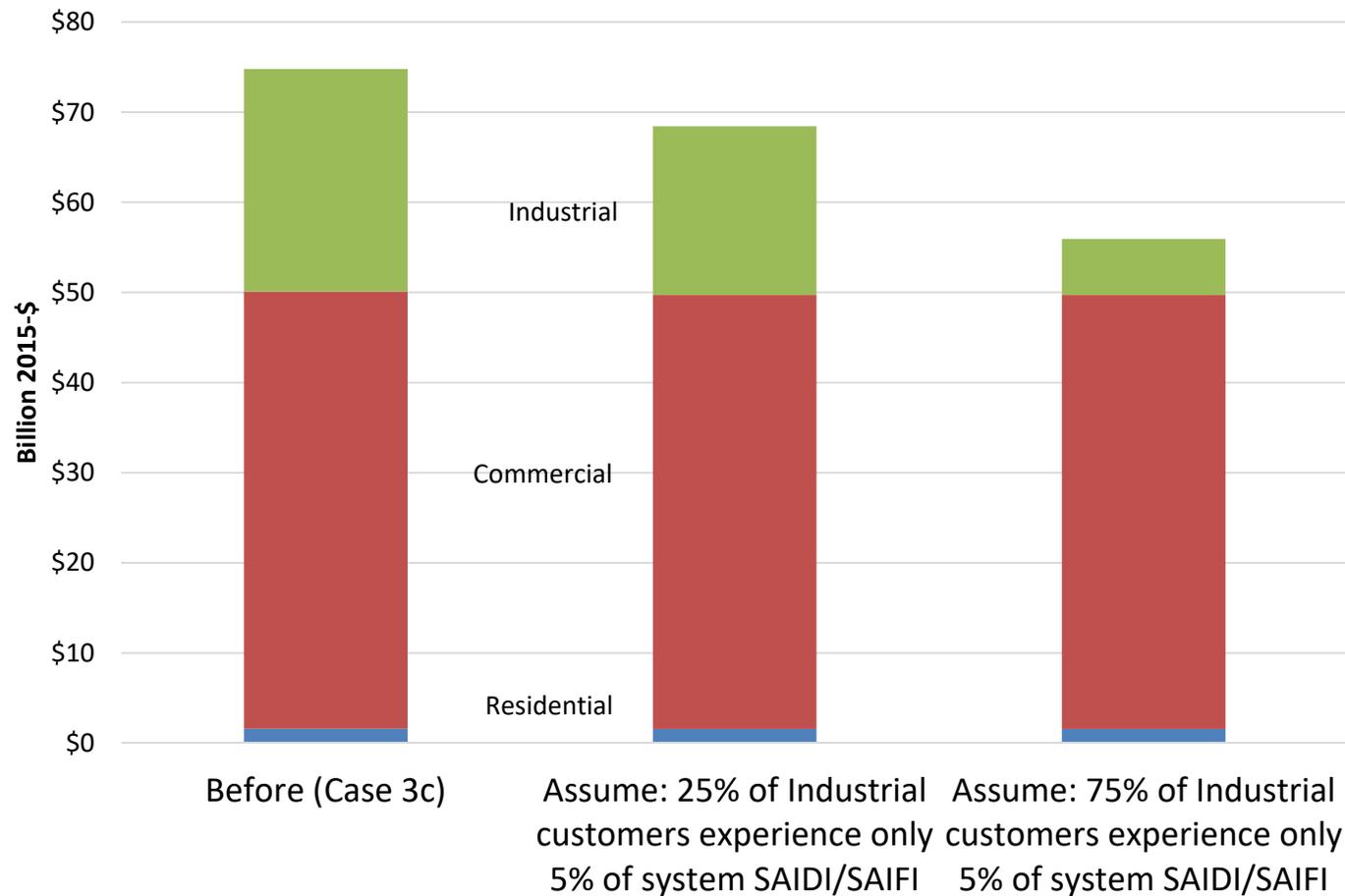


	Residential	Commercial	Industrial
Cost per customer (2015-\$/customer)	\$11	\$2,299	\$19,391
Cost per MWh annual sales (2015-\$/MWh)	\$1	\$31	\$16

Source: U.S. Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report.", Form EIA-861S, "Annual Electric Power Industry Report (Short Form)" and Form EIA-923, "Power Plant Operations Report" for Year 2015

A Sensitivity Study on the Cost of Power Interruptions to Industrial Customers

Industrial customers are often served at sub-transmission and transmission voltages



Source: Assumption of 5% of interruptions due to LOS taken from findings in:

Eto, J., K. H. LaCommare, H. C. Caswell, and D. Till, *Distribution System vs. Bulk Power System: Identifying the Source of Electric Service Interruptions*, submitted to IEEE Transactions on Power Systems, May 2016.



Summary of *Preliminary* Findings

- LBNL is updating its 2004 study of the national cost of power interruptions
- The update is based on a number of improvements in the public information that is now available, in part due to research sponsored by DOE
- LBNL now estimates that power interruptions cost \$59 billion per year (2015-\$), an increase of more than 68% since our initial, 2004 study
- The 13% of customers in the commercial and industrial classes account for more than 97% of these costs

Concluding Remarks

- Power interruptions have economic consequences for customers
- Addressing these consequences is a responsibility that is shared primarily between the customer and its utility, but also in some cases the government at large
- Managing sustained interruptions is a long-standing responsibility of the utility
- Managing severe major events is a responsibility that is shared with government
- Customers always have the option to secure (and pay for) higher levels of reliability