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

Distribution Reliability Working Group
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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

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)

<table>
<thead>
<tr>
<th>What we used for the 2004 study</th>
<th>What we’ve used for the current study</th>
<th>What we would like to use for the next study</th>
</tr>
</thead>
</table>
| Year 2001 customer counts by class using EIA 861 | Year 2015 customer counts by class using EIA 861  
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 | 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)  
**OR**  
A revised ICE Calculator based on a new national interruption cost survey developed based on EIA customer class definitions |
## Frequency and Duration of Interruptions (E)

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<tr>
<td>A convenience sample of readily available public data on SAIDI and SAIFI (with major events) and MAIFI averaged over the entire U.S.</td>
<td>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</td>
<td>A statistically representative, yet enhanced SAIDI and SAIFI-like metric that distinguishes among customers by type AND Metrics that provides for a more explicit representation of the duration of interruptions experienced by customers</td>
</tr>
<tr>
<td>SAIDI converted into distributions of event durations using data collected from utility websites</td>
<td>No estimate of cost of momentary interruptions</td>
<td></td>
</tr>
<tr>
<td></td>
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</table>

SAIDI converted into distributions of event durations using data collected from utility websites.

No estimate of cost of momentary interruptions.
Representation of SAIDI and SAIFI by Census Region

**Pacific**
- Share of customers to U.S. total = 14%
- Share of customers represented by SAIDI and SAIFI = 84%

**Mountain**
- Share of customers to U.S. total = 7%
- Share of customers represented by SAIDI and SAIFI = 79%

**WN Central**
- Share of customers to U.S. total = 7%
- Share of customers represented by SAIDI and SAIFI = 63%

**EN Central**
- Share of customers to U.S. total = 15%
- Share of customers represented by SAIDI and SAIFI = 85%

**Mid-Atlantic**
- Share of customers to U.S. total = 12%
- Share of customers represented by SAIDI and SAIFI = 53%

**South Atlantic**
- Share of customers to U.S. total = 21%
- Share of customers represented by SAIDI and SAIFI = 56%

**ES Central**
- Share of customers to U.S. total = 6%
- Share of customers represented by SAIDI and SAIFI = 31%
Re-expressing SAIDI as a Distribution of Outage Durations

![Graph showing the distribution of outage durations for different regions.]
# Economic Cost of Interruptions (O)

<table>
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<tr>
<td>A meta-analysis that developed customer damage functions (CDFs) based on 24 utility customer surveys administered by 8 utilities between years 1989-2002</td>
<td>An updated meta-analysis that developed new CDFs based on 34 utility customer surveys administered by 10 utilities between 1989-2012</td>
<td>A new, statistically representative national survey of customer interruption costs that supports regional variations</td>
</tr>
<tr>
<td></td>
<td>The CDFs are based on a more advanced, two-part regression model (= the current ICE Calculator)</td>
<td>Augmented by a separate analysis of the cost of long-duration, widespread power interruptions</td>
</tr>
</tbody>
</table>
## Vulnerability (V)

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<td>In the absence of any data, we assumed all customers were vulnerable to power interruptions</td>
<td>We commissioned a study by Frost &amp; Sullivan (2015) to develop regional market penetration estimates of stand-by generators and UPS systems by customer class</td>
<td>Updated and more granular information on stand-by generators and UPS</td>
</tr>
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<td></td>
<td>Augmented by better understanding of the resilience of modern electricity consuming equipment</td>
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</table>
U.S. cost of sustained power interruptions, by step-by-step case and sector, in billion 2015-$

Case 1: The 2004 Study Just Sustained (2002-$)

Case 2a: Case 1 Conversion to 2015-$

Case 2b: Case 2a + 2001 Customer Guesstimate

Case 2c: Case 2b + 2015 Customers

Case 3a: Case 2c + 2015 Updated CDFs

Case 3b: Case 3a + 2015 SAIDI/SAIFI

Case 3c: Case 3b + Vulnerability

Case 4: Case 3c + Distribution of Outage Durations

Billion 2015-$

Residential

Industrial

Commercial

$26

$35

$31

$36

$30

$75

$75

$59

$0

$10

$20

$30

$40

$50

$60

$70

$80
National Cost of Sustained Power Interruptions
$59 billion (2015-$)

- Residential: $1 billion, 28%
- Commercial: $41 billion, 70%
- Industrial: $16 billion, 2%

Graph showing the cost distribution across different regions and customer types.
A Look Behind the Numbers

<table>
<thead>
<tr>
<th>Customer Count (millions)</th>
<th>Electricity Sales (TWh)</th>
<th>Updated US COPI (billion 2015-$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential 129.8 87%</td>
<td>Industrial 998 27%</td>
<td>Residential $1 2%</td>
</tr>
<tr>
<td>Commercial 18.0 12%</td>
<td>Residential 1,407 37%</td>
<td>Commercial $41 70%</td>
</tr>
<tr>
<td>Industrial 0.8 1%</td>
<td>Commercial 1,352 36%</td>
<td>Industrial $16 28%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost per customer (2015-$/customer)</th>
<th>Residential 11 37%</th>
<th>Commercial 2,299 33%</th>
<th>Industrial 19,391 60%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost per MWh annual sales (2015-$/MWh)</td>
<td>1 2%</td>
<td>31 35%</td>
<td>16 35%</td>
</tr>
</tbody>
</table>

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

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

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