The National Cost of Power Interruptions to Electricity Customers - An Early Peek at LBNL’s 2016 Updated Estimate

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Overview/Background

• In 2006, 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 a preview of LBNL’s major update to its 2006 study
In 2006, LBNL estimated that power interruptions cost the US $79 billion annually (2002-$).

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

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LBNL also documented significant uncertainties in its analysis, ranging from $30-130 billion.

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

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 2014 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) |
## 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 and 2014 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 – SAIDI converted into distributions of event durations using data collected from utility websites</td>
<td>A statistically representative, yet enhanced SAIDI and SAIFI-like metric that distinguishes among customers by type, and provides a more explicit representation of the duration of interruptions experienced by customers</td>
</tr>
<tr>
<td>Publicly available, yet limited regional information on MAIFI - provenance is not well understood</td>
<td></td>
<td>Better information on MAIFI</td>
</tr>
</tbody>
</table>
Re-expressing SAIDI as a Distribution of Outage Durations

Fraction of total interruptions

Duration (min)

Pacific | Mountain | West North Central
West South Central | East North Central | East South Central
New England | Middle Atlantic | South Atlantic
# Economic Cost of Interruptions (O)

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<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. The CDFs are based on a more advanced, two-part regression model (= the current ICE Calculator)</td>
<td>A current, statistically representative national survey of customer interruption costs that supports regional variations. Augmented by a separate cost analysis of long-duration, widespread power interruptions. More careful evaluation of the cost of momentary interruptions</td>
</tr>
</tbody>
</table>
## Vulnerability (V)

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<tr>
<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 Augmented by better understanding of resilience of modern electricity consuming equipment</td>
</tr>
</tbody>
</table>
Building Toward an Updated Estimate

PRELIMINARY FINDINGS

NOT FINAL

Case 1: The 2004 study (2002-)
Case 2a: Case 1 + Conversion to 2014-
Case 2b: Case 2a + 2001 Customer Guesstimate
Case 2c: Case 2b + 2014 Customers
Case 3a: Case 2c + Updated CDFs
Case 3b: Taking Case 3a + updated SAIDI, SAIFI, MAIFI
Case 3c: Taking Case 3b + Vulnerability + Distributions
Case 4: Taking Case 3d + Distributions

Monte Carlo uncertainty ± 1 std dev likely between $60-160B

Billion 2014-$

$0 $20 $40 $60 $80 $100 $120 $140 $160

Residential
Commercial
Industrial

$79 $103 $92 $106 $77 $115 $114 $110
Updated National Cost of Power Interruptions
$110 billion (2014-$)

PRELIMINARY FINDINGS NOT FINAL
A Different Perspective on the Cost of Momentary Interruptions

- Momentary interruptions are the result of technology investments by utilities to prevent sustained interruptions
- $60B in momentary interruption costs might otherwise be $157B in sustained interruption costs

PRELIMINARY FINDINGS NOT FINAL
# A Look Behind the Numbers

**Customer Count (millions):**
- Residential: 128.7 (87%)
- Commercial: 17.9 (12%)
- Industrial: 0.8 (1%)

**Electricity Sales (TWh):**
- Residential: 1,407 (37%)
- Commercial: 1,352 (36%)
- Industrial: 998 (27%)

**Updated US COPI (billion 2014-$/):**
- Residential: $3 (3%)
- Commercial: $76 (69%)
- Industrial: $30 (28%)

<table>
<thead>
<tr>
<th></th>
<th>Residential</th>
<th>Commercial</th>
<th>Industrial</th>
</tr>
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<tbody>
<tr>
<td>Cost per customer</td>
<td>$23</td>
<td>$4,257</td>
<td>$35,757</td>
</tr>
<tr>
<td>Cost per MWh annual</td>
<td>$2</td>
<td>$56</td>
<td>$30</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

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

• LBNL has begun an update to 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 – on a preliminary, not yet final basis - that power interruptions cost $110 billion per year (2014-$), an increase of more than 30% since our initial, 2004 study
• The ~13% of customers in the commercial and industrial classes account for more than 95% of these costs
• The cost of momentary interruptions continues to account for a substantial portion 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
• Momentary interruptions result from utility actions to manage (i.e., avoid) sustained interruptions
• 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