IMPROVING ELECTRIC SERVICE RELIABILITY
EMPLOYING EMERGING TECHNIQUES TO SOLVE AGE-OLD PROBLEMS
THE GROWING IMPORTANCE OF RELIABILITY

Electricity reliability is becoming ever more important and visible to consumers. Checking a home camera, sending a command to a Nest thermostat, watching a streamed movie, or charging the array of devices people now own and carry – in addition of course to providing light, heat, and power to household appliances – have all vastly increased customers’ expectations for uninterrupted electric service.

Electric utilities as a group have done remarkably well over the past decade in terms of delivering and improving service reliability. For example, median annual non-storm service interruptions (System Average Interruption Frequency Index or SAIFI) decreased by 16 percent from 2005 to 2010 and by another 11 percent during the following five years (Exhibit 1).

But not every utility has been able to achieve this result. A considerable number of utilities have seen a falloff in reliability, while others are finding further gains increasingly difficult to eke out.

More improvement is possible, however, and utilities today have more tools than ever to drive reliability gains. In assisting utilities over the past several years to improve reliability, we have applied and observed new approaches that can extend and complement tried-and-true solutions, while keeping a lid on costs.

Exhibit 1: System Average Interruption Frequency Index (SAIFI) by Quartile

ANNUAL INTERRUPTIONS PER CUSTOMER, IEEE STANDARD MAJOR EVENT DAYS (MED) REMOVED

Source: IEEE Distribution Reliability Working Group Benchmark Results 2005 to 2015, Oliver Wyman analysis
RECENT RELIABILITY PERFORMANCE

The industry has improved not only interruption frequency but median annual minutes a customer is without service: The System Average Interruption Duration Index or SAIDI improved by 10 percent over the past five years (Exhibit 2). This improvement however has been driven entirely by a reduction in the median number of interruptions. During the same period, the median duration of interruptions (Customer Average Interruption Duration Index or CAIDI) has actually gotten worse for the industry overall, increasing by nearly five percent since 2010 (Exhibit 3).

Exhibit 2: System Average Interruption Duration Index (SAIDI) by Quartile

ANNUAL MINUTES PER CUSTOMER, IEEE STANDARD MAJOR EVENT DAYS (MED) REMOVED

Source: IEEE Distribution Reliability Working Group Benchmark Results 2005 to 2015, Oliver Wyman analysis

Exhibit 3: Customer Average Interruption Duration Index (CAIDI) by Quartile

AVERAGE MINUTES PER INTERRUPTION, IEEE STANDARD MAJOR EVENT DAYS (MED) REMOVED

Source: IEEE Distribution Reliability Working Group Benchmark Results 2005 to 2015, Oliver Wyman analysis
Our analysis shows that at the individual utility level, there is plenty of room to tackle both outage frequency and the more challenging issue of outage duration. A quarter of benchmarked utilities saw SAIFI degrade in the past decade. Eight utilities remain worse than the 2005 median SAIFI, while most utilities experienced slower SAIFI improvement in the past five years compared with the previous five-year period (Exhibit 4). In addition, nearly half of benchmarked utilities have seen CAIDI performance degrade since 2005, and more than half saw worse CAIDI performance in 2015 than in 2010 (Exhibit 5).

Exhibit 4: Change in System Average Interruption Frequency Index (SAIFI) for Benchmarked Utilities, 2005 vs. 2015

ANNUAL INTERRUPTIONS PER CUSTOMER, IEEE STANDARD MAJOR EVENT DAYS (MED) REMOVED

Note: Each point represents an individual utility
Source: IEEE Distribution Reliability Working Group Benchmark Results 2005 to 2015, Oliver Wyman analysis

Exhibit 5: Change in Customer Average Interruption Duration Index (CAIDI) for Benchmarked Utilities, 2005 vs. 2015

AVERAGE MINUTES PER INTERRUPTION, IEEE STANDARD MAJOR EVENT DAYS (MED) REMOVED

Note: Each point represents an individual utility
Source: IEEE Distribution Reliability Working Group Benchmark Results 2005 to 2015, Oliver Wyman analysis
On the flip side, some utilities are demonstrating that it is possible to “move the needle” in terms of improving reliability: Nine of the companies benchmarked have increased both SAIFI and CAIDI by more than ten percent over the past decade.

The approaches we have developed and observed at leading utilities focus on two dimensions simultaneously – reducing both interruption frequency and duration. As described below, interruption frequency improvement involves capital investment and optimizing system maintenance and certain operations expenditures; interruption duration improvement focuses on operational process excellence for restoration response and repair, as well as system design for resiliency and recovery.

**REDUCING FREQUENCY INTERRUPTIONS**

To cut down on the number of service interruptions and improve SAIFI, utilities are investing capital to enhance distribution network design. Top utilities often start with increased sectionalization through the installation of reclosers to reduce the number of customers affected by any sustained outage. Equipment repair, replacement, and maintenance programs are also key components in preventing outages, along with vegetation management programs.

These core strategies appear to be straightforward, but maximizing the benefits from expenditures and effort requires advanced analytics to sharpen the approach. Several lessons taken from our work illustrate how some utilities are developing and using innovative methods to improve their reliability performance.

**DISTINGUISHING SIGNAL FROM NOISE**

Teasing out underlying outage frequency patterns requires an understanding of true causes and effects. This involves differentiating between “preventable” and “unpreventable” outages – a categorization that will depend on what actions are being considered. But in each case, reliability analysis will be more effective if improvement options are analyzed only in relation to relevant “preventable” outages.

For example, when looking to improve feeder or circuit reliability, analysis should focus on the kinds of outages that could be eliminated through feeder-level actions (such as enhanced tree trimming, sectionalizing, or hardening of poles and cables). Outage causes that might be considered “unpreventable” through investment in the distribution system, such as those due to loss of supply, bus outages, and potentially even pole-hits from vehicles, should be excluded from this particular analysis. Considering substation investments, on the other hand, would require a different categorization of outages.
Knowing which outages to consider and where to draw the line is an important step in identifying which feeders and improvement types to invest in. Exhibit 6, a disguised example from a client project, highlights how the categorization of outages to be included or excluded from an analysis greatly affected how feeders were prioritized for reliability improvement investments.

Exhibit 6: Feeder Investment Priority Based on Three Different Methodologies

- Feeders initially targeted for investment
- Selections based on highest total customer interruptions
- Selections based on highest preventable or controllable customer interruptions

Higher priority feeder investments

Individual feeder prioritized and selected for investment

Source: Oliver Wyman analysis

GETTING MORE BANG FOR YOUR BUCK

Developing a system-wide reliability improvement strategy is important, but realizing maximum performance gains from investments requires analysis and focus at the feeder level. We have seen repeatedly that targeted small investments have higher reliability impact per dollar than large blanket distribution projects such as complete feeder rebuilds.

We have developed techniques to estimate the average improvement of different investment categories, thus helping clients prioritize their investment portfolios and drive toward better reliability, faster. Further, marginal cost/benefit analyses at the feeder level can help utilities answer key questions about the implementation of reliability improvement measures. For example: How much to sectionalize – should there be 500 customers per feeder or 350? Should targets vary across the service territory? Should reclosers and circuits be automated; that is, are there sufficient ties and sections (design maturity) to make automation worth the cost? How do I plan for and prioritize these investments?

Drilling into the details to analyze at a feeder (or even segment) level enables the many small investment decisions that can optimize limited funds to improve reliability. While it isn’t simple to apply these advanced analytic techniques, they provide insights into how to deliver greater reliability improvement for each dollar spent – a worthwhile result for a utility and its customers.

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REDUCING INTERRUPTION DURATION

While SAIFI improvements are primarily a matter of design, reducing the duration of outages (improving CAIDI) can be more challenging, as it requires delving into dispatching and field work practices and responsiveness – which can mean changing culture and habits.

Responding more quickly can also increase costs and demand for resources if a company does not also focus on working smarter. Our approach typically starts with developing an “anatomy of an outage” analysis – tying each increment of time to a step in the utility’s restoration process, from outage notification to full restoration (Exhibit 7). Leading utilities make use of monthly “anatomy of an outage” reports to identify and address outlier performance, during particular shifts, or for certain outage types. In some cases, they even link performance results to individual dispatchers or crews.

Working smarter also means being more prepared. Queuing theory is now being used to model the impact of adjustments to optimize staffing levels, shift sizes, and field roles. Some utilities are making these adjustments more dynamically, in response to weather predictions, especially for storm preparation, and using machine learning to improve pre-storm prediction, planning, and preparation.
Exhibit 7: Anatomy of an Outage

Each outage is analyzed by:

- **Time of day** (e.g., business hours, non-business hours, weekends)
- **Weather type** (e.g., “blue sky” vs. minor storm)
- **Crew service centers/work areas**
- **Outage cause**
- **Area of system** (e.g., primary, secondary, substation, voltage level)

### Average Duration of Outage by Time of Day and Restoration Process Step

<table>
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<th>3</th>
<th>4</th>
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<tr>
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IN MINUTES

### Utility Restoration Process (Factors Affecting Restoration Time)

1. **Outage create time**
   - Systems to process efficiently
   - Location and severity analysis

2. **Order created to first assignment/dispact**
   - Dispatch procedures guidelines (including job stacking)
   - Crew acceptance rates
   - After hours issues

3. **First dispatch to final dispatch**
   - Dispatch procedures guidelines (including job stacking)
   - Crew acceptance rates
   - After hours issues

4. **Dispatch to en route time**
   - Crew availability and mobilization time
   - Response parameters

5. **Travel time**
   - Resource scheduling by geography
   - Crew allocation and staging

6. **Restoration**
   - Crew call-in vs. trouble man pair up
   - Line repair procedure
   - Partial restores

Source: Oliver Wyman analysis

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NEXT STEPS FOR UTILITIES

Even the best-performing utilities (perhaps even especially) are driving hard for further reliability improvement. While reliability cannot be achieved through a one-size-fits-all prescription, there are steps being taken by leading utilities that can be of value across the board. Many of these involve advanced analytics, for example, using smart grids and Advanced Metering Infrastructure (AMI) to proactively monitor network health and discover indications of problems before they cause interruptions (momentary outages, line voltage changes, device temperatures, etc.) Data from AMI is also being compared with Outage Management System (OMS) data to validate interruption data, which can deliver improved outage reporting accuracy, increase the accuracy of the OMS network, and directly improve reliability metrics.

In addition, all utilities – whether their reliability has improved to date or not – have the potential to go beyond SAIFI and CAIDI and pursue a more customer-centric perspective on reliability performance. Customers do not necessarily differentiate between momentary and sustained outages. No matter the outage duration – 30 seconds, 30 minutes, or 30 hours – customers feel inconvenienced if they must reset alarm or appliance clocks or operate in the dark for any period of time. Leading utilities are beginning to examine a new version of the Customers Experiencing Multiple Interruptions (CEMI) metric to identify customers and circuits that have experienced abnormally high levels of outages, both momentary and sustained combined, as a means of further improving customer satisfaction.

Customer expectations for highly reliable and uninterrupted electric service will continue to rise, challenging every utility to improve even more in the future. Fortunately, new data, technologies, and tools are available that can help any utility increase reliability within existing budgets. Both leading and lagging utilities can still find opportunities to better their performance and the effectiveness of their reliability-related efforts.
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