A Comparable Method for Benchmarking the Reliability Performance of Electric Utilities

D. A. Kowalewski, *Member, IEEE*

***Abstract*— This paper describes the results of an assessment of various methods of identifying events whose impact on the reliability of electric service to customers is so severe as to dominate reliability statistics and mask the true design quality of the power delivery system or the true operational performance of the electric utility. Alternatives are compared based on realistic applicability within a utility and statistical results when applied to historical data from two major metropolitan areas in the USA. A method based on the lognormal probability distribution applied to daily SAIDI is recommended. This work was part of an effort of the IEEE Power Engineering Society's Task Force on Reliability Indices.**

***Index Terms*—log normal distributions, power distribution reliability, reliability, reliability modeling, benchmarking, reliability indices**

I. Introduction

EXELON Company's energy delivery business unit serves approximately 5 million electric customers in two major U.S. metropolitan areas. In the west is ComEd, with 3.5 million customers in and around Chicago, and in the east is PECO, with 1.5 million customers in and around Philadelphia. The Company continually searches for ways to better understand its own performance and its performance relative to others. Industry-standard reliability measures like system average interruption frequency index (SAIFI), system average interruption duration index (SAIDI) and customer average interruption duration index (CAIDI) are the preferred indices for benchmarking performance within and among electric utilities. However, some events, especially storms, are so severe as to dominate reliability statistics and mask the true design quality of the power delivery system or the true operational performance of the utility. As part of the IEEE Power Engineering Society's task force on electric power distribution reliability indices, the Company has joined with other electric utilities, consultants, academics, and other interested parties in finding fair and reasonable ways to identify these major events. It is intended that utilities will segment major events for careful individual scrutiny, and exclude them from calculations of normal reliability statistics. This paper describes the results of an assessment of various methods of identifying major events, including the results of an application of the candidate methods to ComEd's and PECO's historical reliability data.

Daniel A Kowalewski with Exelon - ComEd., Chicago, IL USA (e-mail: daniel.kowalewski@exeloncorp.com).

II. Assessment of Methods

Following is the Company's experience in assessing methods of identification of major events; in particular our selection criteria, analysis, and conclusions.

A. Selection Criteria

A method of identifying major events for segmentation from benchmarking data must facilitate consistent segmentations, allow fair benchmarking, provide information to understand performance trends, and be repeatable. Desired elements of the method include:

- Clear rules for application and segmentation
- Objective (no subjectivity)
- Scalable to various sized utilities
- Identifies outlying events
- Removes major weather event variability
- Allows trending
- Balances operational concerns
  - Outage frequency
  - Outage duration
- Allows for consistent results
- Ease of calculation

B. Analysis

Various methods were compared by applying them to historical data from ComEd and PECO, and examined the results of other utilities, looking for consistent and understandable results, segmentation differences, impacts of different sized companies, and variability of results. This trading of methodology and results from a broader data set ensures consistent application across utilities and expands understanding.

The alternatives considered include:

- The traditional IEEE definition, which identifies a major event as one that impacts at least 10% of a company's

customers in an operating area during a 24-hour period, applied to ComEd regions, the ComEd system, and the PECO system. [8]

- The bootstrap method, which defines major event days as those whose SAIDI per day, is greater than the worst days per year when comparing to prior years. The identification of SAIDI per day threshold values was based on 3-year and 5-year histories.[7]

- The three-beta method uses five years of SAIDI per day data (or as many as the utility may have up to five). In this method, the natural logarithms of SAIDI per day are calculated to convert to a log normal distribution. The threshold for identification of major event days is then computed using three standard deviations (called beta after the log transformation) above the mean (called alpha after the log transformation). The identification of SAIDI per day threshold values was again based on 3-year and 5-year histories. [1]

- The 6-beta method uses five years of SAIDI per day data (or as many as the utility may have up to five). This method was considered as a way to identify events that are so large that they would completely dominate any multi-year reliability calculations of which they are a part.

- Variations of these and other techniques

TABLE I
ALTERNATIVE COMPARISONS

	Removes Subjectivity	Scalability	Removes Outliers	Removes Weather Variability	Allows Trending	Balances Duration	Balances Frequency	Clear Rules for Exclusion	Ease of Calculation
10% Sys/Region			x				x		x
Boot Strap		x	x			x	x		x
3 Beta	x	x	x	x !	x	x	x	x	x
6 Beta	x							x	x

TABLE II
COMED STORM DAY SEGMENTATIONS

METHOD	1998	1999	2000	2001
Exelon Energy	11	8	10	16
10% Regional	3	0	2	0
10% System	2	0	0	0
Hypothetical Application of 1998 - 2001 Threshold Values				
Bootstrap	7	2	3	0
3 - Beta* (SAIDI per Day)	10	3	5	0
3 - Beta** (SAIDI per Day)	10	2	6	0
3 - Beta*** (SAIDI per Day)	17	4	11	0
6 - Beta (SAIDI per Day)	0	0	0	0

* Base on outage start date

** Based on customer outages by calendar day

*** Based on 24 hour rolling customer outages

Three Beta Methodology (SAIDI per Day -Threshold Calculation) [7]

- Using five years of data (or as many as you have up to five).

- Calculate SAIDI/Day and sort in descending order from highest to lowest (if you have any days with no interruptions, use the lowest day for that year and include those days in the calculations).

- Calculate the natural log (LN function) of each SAIDI value.

- Calculate the mean (α) (AVERAGE function) and standard deviation (β) (STDEV function) of the natural log values.

- Find the threshold using $e^{(\alpha + 3\beta)}$ (EXP function), converts back to SAIDI per day

- The Threshold value is applied to the year following the five-year data analysis period.

- All days with a SAIDI greater than or equal to the calculated Threshold value are considered Major Event Days. Each utility should review and confirm that these days are indeed Major Event Days.

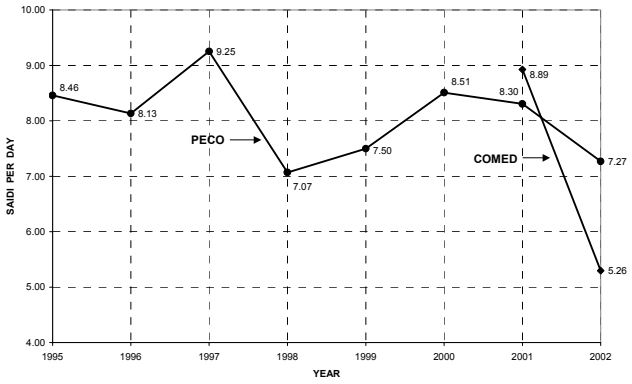

Fig. 1. PECO and COMED thresholds of Daily SAIDI per 3-Beta Method (3-year rolling outage data for PECO and 4-year outage data for COMED)

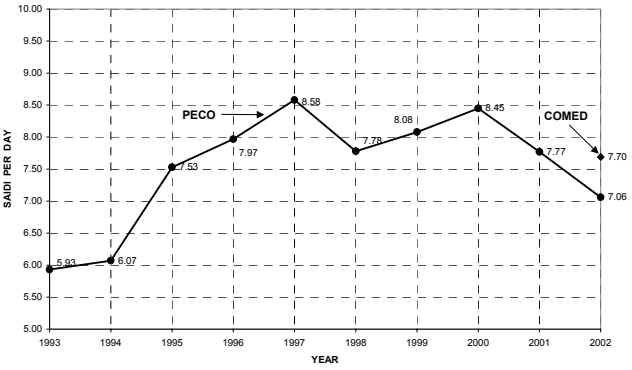

Fig. 2. PECO and COMED thresholds of Daily SAIDI per 3-Beta Method (5-year rolling outage data for PECO and 4-year outage data for COMED)

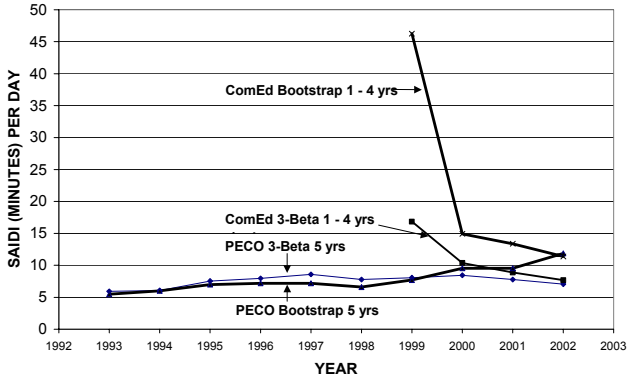

Fig. 3. PECO and COMED 3-Beta versus Bootstrap Daily SAIDI Thresholds

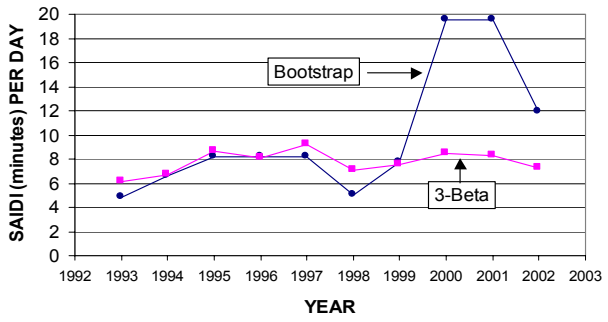

Fig. 4. PECO SAIDI per day Thresholds (3 years of data)

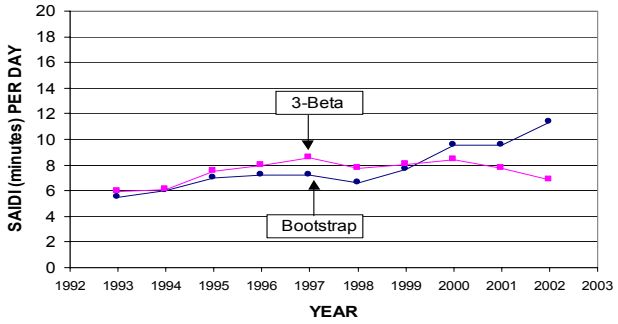

Fig. 5. PECO SAIDI per day Thresholds (5 years of data)

The year-to-year changes in threshold as calculated by the 3-beta method are small compared to the changes as calculated by the bootstrap method, especially if the number of years used in the bootstrap calculation is small. Since many utilities have only a few years of consistent data, the bootstrap method is likely to yield thresholds that exhibit excessive variability.

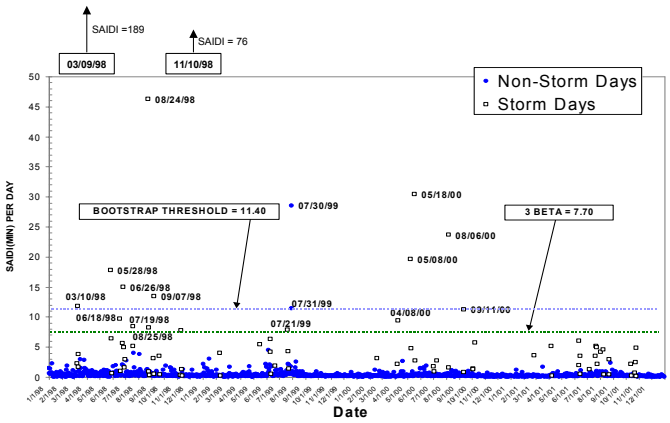

Fig. 6. COMED Daily SAIDI (1998 -2001)

Company management and regulators naturally desire reliability measures that exclude as little information as possible. However, variations in weather tend to have a strong influence on reliability measures, even with the exclusion of major events. Utilities and regulators must carefully consider the comparisons that they may make, such as year-to-year comparisons within the utility, or single-year comparisons among utilities or regions of a single utility. They should explicitly address the weather variability that remains after major event exclusions, and should be prepared to perform normalizations to gauge the true underlying performance.

C. Conclusions

- Recommend using Three-Beta Methodology
- Achieves Objectives
    - Consistent
    - Facilitates Fair Benchmarking
    - Provides Information to Understand Performance Trends
    - Repeatability of Results
- Proven with REAL Data

We recognize that this is not a perfect method (one size fits all), and that electric utilities may be required to continue tracking and reporting Public Utility Commissions' (PUC) State prescribed reliability indices methods and there may also be a need to perform normalization of reliability indices for developing company reliability business plans or other internal uses.

III. Acknowledgment

The author gratefully acknowledges the contributions of Joseph Viglietta, Hector Valtierra and Keith Frost.

IV. References

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