

# Overview of 1366-2001 the Full Use Guide on Electric Power Distribution Reliability Indices

Cheryl A. Warren, *Senior Member, IEEE*

**Abstract—** The purpose of this paper is to introduce and describe the formation of 1366-2001 Full-Use Guide for Electric Power Distribution Reliability Indices. Members of the Working Group on System Design and its Task Force on Distribution Reliability Indices have been working on this project since the late 1980's. This group has grown from a few participants to 150 active members. They have written the Guide to assist utility management, public service commissions, customers, and staff engineers with understanding distribution reliability indices and the factors that affect them. In the last few years there has been a need for 1366 to become more of a benchmarking guideline with strict definitions. The WG and TF have endeavored to address this concern.

*Index Terms*—benchmarking, distribution reliability, major events, and storms.

## I. INTRODUCTION

THIS document describes the formation of the *Full-Use Guide for Electric Power Distribution Indices* IEEE 1366-2001 (“Guide”) and the Working Group and Task Forces that prepared the Guide. The Distribution Subcommittee sponsors the Working Group on System Design. The Working Group on System Design sponsors three Task Forces: 1) The Task Force on System Design, 2) The Task Force on Outage Reporting, and 3) The Task Force on Reliability Indices. This paper will focus on the activities of the Task Force on Reliability Indices (“TF”). The TF has been actively working on the creation of Guide for Electric Power Distribution Reliability Indices for many years. The Trial-Use Guide 1366-1998 was approved in March 1998 and a Full-Use Guide 1366-2001 was approved in March of 2001.

The Guide is used for trending reliability performance, setting the baseline for reliability performance as well as communicating performance to management, key customers, and regulators. There is a wide variance in reported indices between utilities. Some of the reasons for differences will be discussed in this paper.

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Cheryl A. Warren is Principal with Navigant Consulting, Inc., Albany, NY 12203 USA (e-mail: [cwarren@navigantconsulting.com](mailto:cwarren@navigantconsulting.com)). She chairs the IEEE Working Group on System Design and the Task Force on Distribution Reliability.

## II. MAJOR SECTIONS OF THE GUIDE

The IEEE Std. 1366-2001 contains six major sections: 1) Overview, 2) Definitions, 3) Indices, 4) Application of the Indices, 5) Factors that affect index calculation, and 6) Annex. The following subsections will describe each major section.

### A. Overview

The Overview gives the scope and the purpose of the Guide. The scope is reprinted here:

*“This guide identifies useful distribution reliability indices and factors that affect their calculation. It includes indices that are useful today as well as ones that may be useful in the future. The indices are intended to apply to distribution systems, substations, circuits, and defined regions.*

Since its inception, the TF has worked to satisfy the stated scope. Over the last few years however, several entities have asked that language in the Guide be strengthened to make it easier to apply to benchmarking activities and to make it easier for public service commissions to use as a baseline for regulation. Today, making the definitions clearer is the main objective of the TF.

### B. Definitions

There are twenty-one definitions in the Guide. The difference in interpretation of these definitions is one of the reasons that a wide variance exists between reported performance of utilities. The TF has been focusing on the definition of *Major Event* for the past year. In 1366-1998, the definition of Major Event was:

*“A catastrophic event that exceeds design limits of the electric power system and that is characterized by the following (as defined by the utility):*

- a) Extensive damage to the electric power system;*
  - b) More than a specified percentage of customers simultaneously out of service;*
  - c) Service restoration times longer than specified.*
- Some examples are extreme weather, such as a one in five year event, or earthquakes.”*

In 1366-2001, the definition changed to:

*“Designates a catastrophic event which exceeds*

*reasonable design or operational limits of the electric power system and during which at least 10% of the customers within an operating area experience a sustained interruption during a 24 hour period.”*

Since that time the TF has explored methodologies created by Richard D. Chrisite, Charles W. Williams, and James D. Bouford that are designed to statistically identify abnormal system performance. These gentlemen have written papers for this panel session describing the statistics behind the proposed methodologies. It appears at the time of this writing that a Beta Methodology<sup>1</sup> will be adopted as the next Major Event definition. Please see section III. Major TF Initiatives.

The group plans to prepare documentation explaining the basis for the new statistical method. Other definitions that the TF will focus on over the next 12 months include: customer count, interruption and step-restoration.

### C. Indices

This section describes distribution reliability indices including SAIFI, SAIDI, CAIDI, CTAIDI, ASAI, ASIFI, ASIDI, CEMI<sub>n</sub>, MAIFI, and CEMSMI<sub>n</sub>. Customer based sustained indices include: SAIFI, SAIDI, CAIDI, CTAIDI, ASAI. Load based sustained indices include: ASIFI, ASIDI. Momentary indices include CEMSMI<sub>n</sub>, MAIFI and MAIFI<sub>E</sub>. The newest indices are CEMI<sub>n</sub>, Customers experiencing multiple interruptions, and CEMSMI<sub>n</sub>, Customers experiencing multiple sustained interruptions and momentary interruptions events. Many states are now considering use of CEMI<sub>n</sub> as a basis for performance. In Florida, they are considering using CEMI<sub>5</sub>. If this value is exceeded, the commission is considering fines that would be paid to the customers who experienced poor performance.

### D. Application of the Indices

This section shows examples of index calculation based on a fictional database. Collection of interruption data is one of the largest sources of error when reporting performance. Some utilities have very sophisticated systems that contain fully connected models. A fully connected model allows a utility to know exactly how many customers are connected, exactly where they are connected and how they relate to one another. Utilities that have a fully connected model that is integrally tied to their outage management system (“OMS”) and their geographical information system (“GIS”) with automated mapping and facility management systems (“AM/FM”) often have the most accurate reliability indices. Surveys have been performed that show most utilities experience a 25% to 75% increase in their reliability indices the year after they automate their systems. This translates to a perceived degradation in service that is really a collection anomaly. The increased indices come from a more accurate customer count for both customers served as well as

customers interrupted.

### E. Factors that Affect the Calculation of Reliability Indices

This section discusses the recommendation of exclusions from index calculation. The Guide recommends that utilities report indices two ways: 1) including everything and 2) excluding a well-defined subset of data. The typical exclusions include major events and momentary interruptions.

### F. Annex

This section contains results from previous reliability surveys that the task force performed of US utilities. There is also a section on major event definitions from an EEI survey. The group plans to continue expanding this section with other pertinent information that they develop.

## III. MAJOR TF INITIATIVES

The TF has been meeting at the IEEE PES winter and summer power conferences. In addition to the bi-annual meetings, the group has been meeting using an Internet based meeting application (Webex). The Internet meetings have been occurring approximately every six weeks, which has facilitated continuing standards activities. The main focus of activity has been discussion of the *Major Event* definition.

### A. Major Event Definition

Many groups felt that the current definition was not adequate for comparison of indices between utilities. There was little basis for the existing 10% for 24-hour definition. The group felt strongly that the foundation of the new definition should include the following concepts:

- Create a methodology to partition data into “normal” and “abnormal” operating days,
- Suggest rigorous reporting on “abnormal” days through a separate process,
- Use the “normal” operating days for trending, goal setting, benchmarking and reporting,
- Create a definition that is easy to apply, understandable by all, and specific,
- The definition must be equitable for both large and small utilities.

A group of TF members worked diligently to create test methodologies including 1) the natural breakpoint method (James D. Bouford), the boot strap method (Richard D. Christie), 3) the distribution fit method (Richard D. Christie), 4) the three sigma method (Charles W. Williams), and 5) three beta method (James D. Bouford, Richard D. Christie, John McDaniel, Rodney Robinson, David J. Schepers, Hector Valtierra, Joe Viglietta, Cheryl A. Warren, and Charles W. Williams). Virtually all the TF members provided data and or data analysis to test the methods (please see a list of members in the acknowledgements section).

At the time of this writing, it appears that the Beta methodology will be chosen as the new method for defining major events. The steps to apply the beta method are:

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

<sup>1</sup> Please see Section III. Major TF Initiatives for explanation of the Beta Method.

2. Create columns of data with date, year, CMI per day, and SAIDI per Day. Also include the customers served.
3. If there are any zero days, use the lowest value in the set for that day.
4. Order the SAIDI/Day from Highest to Lowest
5. Calculate the natural log (LN function) of each value.  $\ln(\text{SAIDI}/\text{day})$
6. Calculate the mean ( $\alpha$ ) (AVERAGE function) and standard deviation ( $\beta$ ) (STDEV function) of the natural log values.
7. Find the threshold by  $e^{(\alpha + 3\beta)}$  (EXP function).
8. For the following year of data, segment the days above the threshold into the abnormal group.

The group plans to prepare power point and word presentations and papers for use in describing the new process and benefits.

### B. Cause Codes

Before the major event discussion, the group was focused on adding a section to the guide on standard cause codes. This section is a work in progress. The current minimum set of causes codes include:

- Animals
- Lightning
- Major Event
- Scheduled
- Trees
- Overload
- Error
- Supply
- Equipment Malfunction
- Other
- Unknown

There is a wide variance in the industry and even within a company on the way cause codes are assigned. Those using this data to make economic decisions need to factor in the attendant error in cause code recording during their processes. The group is also exploring weather codes, isolating device codes, and failed equipment codes.

### IV. SUMMARY

The TF on Distribution Reliability Indices is a very active group that continues to update and enhance the Full-Use Guide on Electric Power Distribution Reliability Indices 1366-2001. The group is always looking for more participation. If you have an interest in assisting with standards developments, please contact Cheryl A. Warren for more information.

The Guide is useful for trending reliability performance for both internal and external utility uses. Public Service Commission and customers sometimes require information about reliability performance. Utility executives set incentive goals based on reliability indices. Survey groups such as EEI use the guide as the basis for their surveys. Reliability and planning engineers use indices to track reliability performance and adjust design and operations parameters based on

performance. The indices used by the aforementioned people are defined in the Guide. In the future, the Guide is likely to be used more extensively for benchmarking and possibly for regulation.

### V. ACKNOWLEDGMENT

The author gratefully acknowledges the contributions of the Task Force members. This is the most active group that the author has had the pleasure of working with and she wants to commend their activities. The task force membership includes:

John Ainscough: Xcel Energy  
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 Gene Baker : Progress Energy - Florida Power  
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 Jerry Batson: Alliant Energy  
 Steve Benoit: Minnesota Power  
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 Roy Billinton, D.Sc., P.Eng.: University of Saskatoon  
 Dave Blew: PSE&G  
 Math Bollen: Chalmers University of Technology  
 Jim Bouford: National Grid  
 Richard Brown: ABB  
 Joe Buch : Madison Gas and Electric  
 James Burke: ABB  
 Ray Capra : Consultant  
 Mark Carr: American Electric Power  
 Donald M. Chamberlin : Northeast Utilities  
 Jim Cheney: Arizona Public Service  
 Simon Cheng: Puget Power  
 Dave Chetwynd: BC Hydro  
 Ali Chowdhury: MidAmerican Energy  
 Rich Christie: University of Washington  
 Rob Christman: FPL  
 Larry Conrad: Cinergy Corp  
 Ed Cortez: Stoner Associates Inc.  
 Grace Couret: Florida Power & Light Company  
 Tim Croushore: Allegheny Power System  
 Peter Daly: Power System Engineering  
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 Charlie Fajjvandratt: NCI  
 Doug Fitchett: AEP  
 Robert Fletcher: Snohomish County PUD  
 Mahmud Fotuhi-Firuzabad: University of Saskatoon  
 Keith Frost: Commonwealth Edison  
 Chris Gedemer: Advantica Stoner  
 Peter Gelineau: Canadian Electricity Association  
 David Gilmer: Yampa Valley Electric Association  
 Jeff Goh: PG&E  
 Manuel Gonzalez: Reliant Energy  
 John Goodfellow: ECI  
 Robert Y. Goto: Los Angeles Dept. of Water and Power  
 John Grainger: University of North Carolina  
 Don Hall: CES International  
 Mark Halpin: Mississippi State University  
 Dennis Hansen: PacifiCorp  
 Randy Harlas: El Paso Electric Company  
 Mostafa Hassani: PEPSCO  
 Harry Hayes: Ameren  
 Charles Heising: Alaska Power & Telephone Company  
 Eric Helt: PECO Energy (An Exelon Energy Company)  
 Richard Hensel: Consumers Energy Company

Jim Hettrick: MidAmerican Energy  
 Francis Hiramami: Hawaiian Electric Company  
 Dennis B. Horman: Utah Power & Light Co.  
 George E. Hudson: Virginia Power  
 Brent Hughes: BC Hydro  
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 Kevin Jones: Advantica Stoner  
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 Mark Kempker: AES - IPALCO  
 John Kennedy: GA Power Company  
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 Gene Lindholm: AES/CILCO  
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 Mike Marz: Cooper Power Systems  
 Jim McConnach: Ontario Hydro Services Company  
 John McDaniel: Detroit Edison Co.  
 Stephen Middlekauff: CP&L  
 Bill Montgomery: Con Edison  
 J.C. Montgomery: Detroit Edison Co.  
 Chris R. Mueller: RTE Zellweger  
 Jerry Murray: Oregon PUC  
 Peter Nedwick: Dominion - Virginia Power  
 D.L. Nickel: ABB Power T&D Company, Inc. Transmission Technology Institute  
 R.S. Nowell: Georgia Power Company  
 Helyne Noyes: LA Dept of Water and Power  
 Gregory Olson: Public Service Electric & Gas  
 Anil Pahwa: Kansas State University  
 Dan Pearson: PGE  
 Theodore Pejman: USDA-RUS  
 Christian Perreault: Hydro Quebec  
 Charles Perry: EPRI - PEAC  
 Manuel S. Peters: Memphis Light Gas & Water  
 Ray Peters: Tampa Electric Co.  
 Robert Pettigrew: Beckwith Electric Company  
 C.Y. Pi: Moore Systems  
 Steven L. Puruckner: ORNL  
 Steve Quade: Northern States Power Company  
 Ignacio Ramirez-Rosado: University of La Rioja  
 Wanda Reader: Exelon  
 Vittal Rebbapragada: S&C Electric Company  
 John Redmon: John R Redmon, Inc.  
 Sebastian Rios: Catholic University Chile  
 D. Tom Rizy: Martin Marietta Energy Syst. Inc. Oak Ridge National Lab.  
 Rodeny Robinson: Western Resources  
 Fred A. Rushden: Rushden Consulting & Research  
 David Russo: Seattle City Light  
 Dan Sabin: Electrotek Concepts  
 Shafi Sabir: Scarborough PUC  
 Jim Sagen: Fort Collins Light & Power Dept.  
 Bob Saint: NRECA  
 Joe Santuk: Dominion - Virginia Power  
 Dave Schepers: Ameren  
 Ken Sedziol: Cinergy  
 Michael Sheehan: Puget Sound Energy  
 Tom Short: EPRI-PEAC  
 Hari Singh: Cooper Power Systems  
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 Hector Valtierra: Exelon  
 S.S. (Mani) Venkata: Iowa State University  
 Joe Viglietta: PECO Energy (An Exelon Energy Company)  
 Marek Waclawiak: United Illuminating Co.  
 Daniel J. Ward: Dominion - Virginia Power  
 Carl Warn: Rochester Gas & Electric Corp.  
 Neil Weisenfeld: Con Edison  
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 Lee Welch: Georgia Power Company  
 Val Werner: Wisconsin Electric  
 Charlie Williams: Progress Energy - Florida Power  
 Bill Winnerling: EPRI  
 Mike Worden: NY PSC

## VI. REFERENCES

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## VII. BIOGRAPHIES

**Cheryl A. Warren** graduated from Union College in 1987 with a BSEE. She worked for Central Hudson Gas and Electric for two years in the Electric Protection Section performing distribution protection studies. In 1989, Mrs. Warren was given a fellowship at Union College to complete here MSEE degree, which she earned in 1990. She went to work for Power Technologies, Inc. (PTI) in 1990 where she worked until 1999. At PTI, Mrs. Warren worked in the distribution engineering group for five years. She managed distribution software (PSS/U and the PSS/Engines) for three years and then resumed full time consulting in reliability and power quality. Mrs. Warren joined Navigant Consulting, Inc. in 1999. She is a Principal in the Electric and Natural Gas Distribution Group where she leads reliability and distribution based engagements. Mrs. Warren chairs the IEEE WG on System Design and the Task Force on Distribution Reliability Indices. She was awarded the Technical Committee award