



IEEE Guide for Collecting, Categorizing, and Utilizing Information Related to Electric Power Distribution Interruption Events

IEEE Power and Energy Society

Developed by the
Transmission and Distribution Committee

IEEE Std 1782™-2022
(Revision of IEEE Std 1782-2014)



STANDARDS

IEEE Guide for Collecting, Categorizing, and Utilizing Information Related to Electric Power Distribution Interruption Events

Developed by the
Transmission and Distribution Committee
of the
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Approved 13 May 2022

IEEE SA Standards Board

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Abstract: Electric power system reliability remains an important societal issue. Transmission disturbances draw national attention and scrutiny, but service interruptions at the distribution level are the primary concern of end-use customers and their regulatory and governmental representatives. Much effort has been expended on developing methods to uniformly and consistently quantify the reliability of distribution service based on the distribution grid's performance. The collection, categorization, and use of information related to electric power distribution interruption events are discussed in this guide. When combined with IEEE Std 1366™, consistency in how the industry collects data for the purpose of benchmarking distribution system performance, is achieved.

Keywords: benchmarking, data collection, IEEE 1782™, IEEE 1366™, outage management systems, power distribution reliability, reliability management, sampling methods

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Introduction

This introduction is not part of IEEE Std 1782-2022, IEEE Guide for Collecting, Categorizing, and Utilizing Information Related to Electric Power Distribution Interruption Events.

This guide was assembled to provide information regarding the collection, utilization, and categorization of information related to electric power distribution interruption events, which supports both benchmarking across systems as well as development of actions to alter the performance of the electrical network. The aim of this guide is to foster uniformity and consistency in utilities' collection of data on electric power distribution reliability trends and benchmarks to enable meaningful assessment of the reliability performance of different electric utilities. In addition, this guide is intended to provide education and guidance on assessing, identifying trends in, and benchmarking practices related to electric power distribution system reliability. Reliability performance has a significant impact on key stakeholders, including end-use electricity customers, utility companies, and governmental entities. Widespread attempts to benchmark and compare different entities' electric power distribution reliability indicate an industry need for this information. The guide describes recommended data collection, utilization, and categorization practices that should be followed to help ensure fair and accurate comparisons of trends and benchmarks. The Distribution Reliability Working Group recognizes that this guide has been informed and enhanced by a broad set of stakeholders. The Working Group appreciates the input of policy makers, practitioners, and academics to both the scope of this guide and the application of data-driven reliability analysis and improvements.

Previous benchmarking of distribution system reliability aimed to enable utilities to compare themselves to peers. The previous version of this guide (IEEE Std 1782™-2014) established methods to help ensure valid and consistent comparisons and provided guidance for analyzing and categorizing information that the industry has used to drive reliability improvement initiatives. This guide complements IEEE Std 1366™, which defines a methodology to segment data.¹

Emergence of new technologies and industry's need for further stratification of the ten interruption cause codes defined in the previous version of this guide have led to this current revision of the guide, which introduces cause code subcategories that allow for detailed categorization and evaluation of interruptions. This revision also discusses use of the interruption cost estimate (ICE) calculator, the incorporation of smart distribution technology, and advancements in reliability improvement programs. Finally, this revision expands the previous version's discussion of the importance of outage data collection and augments guidance on this topic. The aim of these efforts is to enhance the application of utility reliability data.

The discussion of data collection procedures is broken down into three topics:

- a) Data consistency and categorization for benchmarking surveys
- b) Data collection within the electric power distribution industry
- c) Data usage and practices

Acknowledgments

The Distribution Reliability Working Group wants to recognize the work and time its members contributed to create and revise this guide. In particular, the Working Group appreciates the work of the original authors who are no longer actively working on the guide: Jim Bouford, Keith Frost, Dave Lankutis, Rodney Robinson, Bob Saint, Cheryl A. Warren, and Val Werner.

¹ Information on references can be found in Clause 2.

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1. Overview

1.1 Introduction

Benchmarking of distribution reliability performance has become commonplace in the electric power industry over the past several years despite the fact that useful comparisons are often difficult to make due to the data collection methods employed, differences in system design and operation, and differences in the environments. Many benchmarking studies have been established, each with its own criteria to define how data should be provided and analyzed. In order to arrive at meaningful conclusions, consistent interruption event data and categorization of that data are desirable (Werner et al. [B9]).¹ IEEE Std 1366™ has defined a methodology that, if used, will provide a common way to segment data.² The purpose of Interruption Reporting Practices Guide is to define data collection procedures. Clearly this is a large topic; therefore, this guide has been broken into the following three issues:

- a) Data consistency and categorization for benchmarking surveys
- b) Data collection within the electric power distribution industry
- c) Data usage and practices

1.1 Scope

This guide provides information regarding the collection, utilization, and categorization of information related to electric power distribution interruption events for the purpose of comparing the system reliability of different utilities' systems and underlying actions to change the performance of the electrical network comparisons.

² Information on references can be found in Clause 2.

1.2 Purpose

The purpose of this guide is to foster uniformity and consistency of collection of data among utilities ~~for in the~~ trending and benchmarking ~~of~~ electric power distribution reliability, to enable meaningful assessment of the reliability performance of different electric utilities. In addition, this guide is intended to provide education and guidance ~~on with~~ the assessing trends ~~assessment, trending,~~ and benchmarking practices related to electric power distribution system reliability.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*)^{2,3}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

² The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

³ The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std 1366™, IEEE Guide for Electric Power Distribution Reliability Indices.^{3,4,5}

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁶

There are no definitions in this version of the standard.

3.2 Acronyms and abbreviations

AMI advanced metering infrastructure

BIL basic insulation level

CAIDI customer average interruption duration index

C&I commercial and industrial

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^{5,4} IEEE publications are available from The Institute of Electrical and Electronics Engineers ([https](https://standards.ieee.org/) ~~http~~://standards.ieee.org/).

⁶ IEEE Standards Dictionary Online is available at: <http://dictionary.ieee.org>. An IEEE account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

<u>CELID-s</u>	<u>customers experiencing long interruption durations/single interruption duration</u>
<u>CEMI</u>	<u>customers experiencing multiple interruptions</u>
<u>CEMSMI</u>	<u>customers experiencing multiple sustained & momentary interruptions</u>
<u>CI</u>	<u>customers interrupted</u>
<u>CIS</u>	<u>customer information system</u>
<u>CME</u>	<u>customer minutes interrupted</u>
<u>CPI</u>	<u>circuit performance indicator</u>
<u>DER</u>	<u>distributed energy resource</u>
<u>GIS</u>	<u>geographic information system</u>
<u>ICE</u>	<u>interruption cost estimate</u>
<u>IVR</u>	<u>interactive voice recognition</u>
<u>ME</u>	<u>major event</u>
<u>MED</u>	<u>major event day</u>
<u>NERC</u>	<u>North American Electric Reliability Corporation</u>
<u>O&M</u>	<u>operations and maintenance</u>
<u>OMS</u>	<u>outage management system</u>
<u>ROW</u>	<u>right-of-way</u>
<u>SAIDI</u>	<u>system average interruption duration index</u>
<u>SAIFI</u>	<u>system average interruption frequency index</u>

SCADA supervisory control and data acquisition

SF storm factor

4. Data consistency and categorization for benchmarking surveys

4.1 Overview

This clause ~~portion of the guide~~ presents suggestions for comparing utility reliability performance ~~on comparison of utilities~~ based on a high-level categorization of interruption related data. It aims ~~is not meant to limit how detailed the collection of data could be, or to say what must be collected, rather~~ to define the minimum set of data collection categories required for benchmarking and to help ensure that ~~give consistency to~~ those categories are consistent. However, the definitions in this clause are not meant to limit the degree of detail in the data that a utility collects, or to say what data should be collected.

This guide describes a minimum set of data and a consistent categorization structure needed for comparison of distribution system performance among utilities. This structure includes the following categories: system characterization, interruption cause(s), responsible systems, conditions, voltages, devices, device initiation, and restoration.

Differences among data ~~When performing benchmarking studies, the differences between the collection methods, the locations, and the differences in system designs design~~ can make benchmarking comparisons ~~comparison~~ difficult. Elements ~~Examples of the types of items~~ that may be relevant to ~~when performing~~ benchmarking studies are listed in the next subclause below.

4.1.1 Collection methods and definitions

Inconsistencies in the ways that data are collected, the definitions of the data points that are collected, and the nature of different utilities' systems make it difficult to compare data among different sources. The following list identifies sources of inconsistency in system interruption data:

~~A variety of methods available for collecting data, some listed below, could lead to issues when comparing data in benchmarking surveys.~~

- ~~The~~ Differences in ~~the interruption~~ data collection systems (ranging from ~~manually entered~~ paper systems with manual entries to completely automated, computer-based systems).
- Variations in the ability to collect interruption data from the distribution system, ~~often the result of incomplete circuit topology and data connectivity from which to infer outage impacts~~ (~~ranging~~ from the substation level ~~down~~ to the customer service drop).
- ~~The~~ Use, or lack of use ~~nonuse~~, of step restoration when collecting interruption data.
- Differences in how interruption ~~The determination of the~~ start time is determined.
- Differences in the definition of what constitutes a sustained interruption ~~may play a role~~ (ranging from longer than 1 min to longer ~~greater~~ than 5 min).
- Differences in the definition of a customer (account, meter, premise, etc.).
- Differences in delineation of the type of interruption ~~delineations~~ (unplanned ~~interruptions~~, planned ~~interruptions~~, major event ~~events~~, etc.).
- Differences in definition of, or insufficient information about, the location of the fault that causes an interruption.
- Differences in system design.
- Utilities may contain customers with or without smart meters; moreover, the reporting resolution of the meters may be different (hourly, 15 min, etc.). The detection and interpretation of interruptions may vary from one area to another.

The following subclauses discuss fault location and system design in more detail.

4.1.2 Location

"Location" refers to the specific site where a fault occurs, which is not necessarily the location of the device that operated to clear the fault, also known as the "fault location." Identification of fault locations could allow for enhanced application of protection devices and schemes in addition to other targeted reliability improvement activities (IEEE Std 1806™ [B3]).⁷ In some cases, a difference in location could affect comparisons among data in benchmarking surveys. In many cases, knowing both the sustained and momentary locations of faults can lead to a broad understanding and characterization of system reliability. For example, knowing the locations of momentary events could enable evaluation and action to prevent a sustained event. The following information is relevant to identifying location:

- Physical location within a system (pole number, latitude and longitude, etc.)

~~In some cases, a difference in locale could also lead to issues when comparing data in benchmarking surveys.~~

- System characterization (rural, suburban, urban, networked)
- Climatic information (hot, cold, wet, dry, lightning, etc.)

For additional information on methods to use protection relays, digital fault recorders, traveling wave locators, and power quality monitors for fault location, refer to IEEE Std C37.114™ [B2].

4.1.3 System design

~~In addition, the~~ Differences in system design could lead to data comparison issues ~~when comparing data~~ in benchmarking surveys. Critical elements of system design are as follows:

- System layout (radial, loop, two transformer station, etc.)
- System placement (underground or overhead)

⁷The numbers in brackets correspond to those of the bibliography in Annex E.

For example, underground and overhead electrical distribution systems are exposed to different external and internal factors that can result in a customer interruption. Generally speaking, knowing whether an outage occurred within an overhead or underground system enables improved understanding of system performance and outage causes. However, outages can result from equipment at the interface of these two systems and the initiating fault could incorrectly be attributed to the wrong design type, should there be incomplete understanding of how to differentiate; for instance, a fuse transitioning from overhead to underground could be the isolation point for a deteriorating underground network and the fault could be improperly associated with an overhead cause.

In addition, the method for recording the fault location is different for underground and overhead systems. Generally, the geographical address of the nearest pole to the fault on the overhead system is recorded while the distance along the cable (or nearest access point) is used for fault location recording in underground systems. This can also lead to inconsistencies comparing predominantly overhead systems with predominantly underground systems for benchmark comparisons.

~~This guide includes a minimal set of data and a consistent categorization structure necessary for comparison of distribution system performance. Presented are categories for system characterization, interruption causes, responsible systems, conditions, voltages, devices, device initiation, and restorations~~

4.2 Data collected during the interruption event ~~process~~

Data that should be collected during an interruption event are as follows:

— Cause of the interruption

~~As part of the interruption event collection process, the cause is collected with other pertinent information. This information should include:~~

~~— The~~ Number of customers interrupted (CI)

- ~~The~~ Interruption duration ~~duration~~s, based on start date/time and restore date/time
- ~~The~~ Number of customer minutes of interruption (CME ~~CMI~~)

As the database is maintained over time, analyses can use ~~the years, cause~~ information about the causes of interruptions ~~can be used~~ in combination with the number of interruption events, the ~~number of~~ CI, and the CMI. Some of the purposes ~~number~~ of those analyses are ~~CMI to numerous analytical ends, some of which will be~~ discussed in 4.4 and 4.5 ~~this document~~.

4.3 System characterization

It is important to identify the composition of the utilities participating in a benchmarking study. Utility circuits (and systems) generally fall into one ~~The characterizations~~ of the following utility system are usually broken into the three categories, which below. ~~The categories~~ are defined by customer ~~the customer's density as shown below~~.

- Rural (less than 31 customers per circuit kilometer or 50 customers per circuit mile)
- Suburban (31 to through 93 customers per circuit kilometer or 50 to through 150 customers per circuit mile)
- Urban (more ~~greater~~ than 93 customers per circuit kilometer or 150 customers per circuit mile)

The percentages ~~of the number~~ of circuits represented by ~~are applied to~~ each of the categories are used above to describe the makeup of each utility.

~~As observed in~~ Table 1 outlines below, a simple system composed of five ~~the~~ circuits, identifying their individual characterization ~~outlined below should be treated as shown below~~.

Table 1—System characterization example (percent number of circuits)

	Circuit length (km)	Circuit customers	Customers/circuit length (km)	Circuit designation
Circuit A	14	100	7	Rural
Circuit B	50	2000	40	Suburban
Circuit C	12	1500	125	Urban
Circuit D	20	500	25	Rural
Circuit E	27	1000	37	Suburban

(New)

	Circuit length (km)	Circuit customers	Customers/circuit length (km)	Circuit designation
Circuit A	14	100	7	Rural
Circuit B	50	2000	40	Suburban
Circuit C	12	1500	125	Urban
Circuit D	20	500	25	Rural
Circuit E	27	1000	37	Suburban
	Urban	Suburban	Rural	
Percent of circuits with system designation	20%	40%	40%	

(Deleted)

For benchmarking purposes when considering the utility's system as a whole, different approaches are pursued among utilities to identify their system characterization. One approach is to look at the percentages of the system in each of the categories above to describe the makeup of the system. For this purpose, either of three percentage values may be utilized: percentage of circuits in each category, percentage of miles/kilometers of each category, or percentage of customers in each category. For instance, for the system presented in Table 1, values presented in Table 2 can be calculated. Based on the practice of the utility, the system could be characterized as "suburban" based on the circuit length or customer breakout or "rural/suburban" based on number of circuits.

Table 2—System characterization example (percent number of circuits)

	Urban	Suburban	Rural
Percentage of circuits in each category	20%	40%	40%
Percentage of circuit length in each category	9.8%	62.6%	27.6%
Percentage of customers in each category	29.4%	58.8%	11.8%

(New)

Another approach is to utilize the same metric used for categorizing circuit customer density to the overall system-level characterization. By doing so, the example system presented could be characterized as suburban based on the calculation of 41.5 customers per kilometer (total customers divided by total circuit kilometers).

While combining these circuits and labeling them by the system's characterization may facilitate benchmarking studies, the benefits of using more granular circuit data may be lost. For example, studying each circuit using the combined system-level characterization may limit mitigation strategies as an urban circuit C or rural circuits A and D could be labeled suburban based on system characterization.

4.4 Interruption cause categories

Ten general interruption cause categories are suggested for use ~~comparison~~ in benchmarking comparisons ~~studies~~. These categories are intentionally broad, to allow for ~~categories that will make possible more~~ precise benchmark comparisons possible among ~~between~~ different distribution utilities. Many ~~There are numerous~~ categories of causes ~~that~~ could be used; ~~chosen, but with the goal of uniformity for comparison purposes,~~ the following 10 ~~ten~~ categories were chosen with the goal of establishing uniformity to facilitate comparisons:

- a) Equipment
- b) Lightning
- c) Planned
- d) Power supply
- e) Public
- f) Vegetation
- g) Weather (other than lightning)
- h) Wildlife

- i) Unknown
- j) Other

These categories are suggested to create a uniform framework for data for benchmark studies, but utilities are free and encouraged to collect more detailed data. For the purpose of benchmarking studies and comparisons, the data should be able to fit into one of these 10 categories, including the subcategories that are recommended in this revision of this guide (4.5). The subcategories allow for collection of more detailed, granular data than were available to be used in previous benchmarking studies.

The outage interruption cause categories and subcategories should reflect the external driver that caused the disruption to the electricity distribution system and resulted in a service interruption to affected customers. Some in the industry refer to this as the "initiating cause" of the service interruption.

~~The recommended categories do not prevent a utility from collecting more detailed data, and that is indeed encouraged. However, the data collected should be able to be placed into one of the ten categories recommended~~

The following list describes ~~paragraphs describe~~ the types of interruptions that should be put into each category. It is ~~Of course,~~ not ~~every~~ possible to address every potential type of interruption, ~~can be discussed,~~ but ~~for most interruptions,~~ the choice of category and subcategory is apparent for most interruptions. The cause categories are discussed in the order ~~as~~ presented above.

- a) Equipment—Any interruption caused by a piece of ~~the~~ distribution system equipment that is defective or fails and causes an interruption of service to customers ~~to customers should be put in the equipment category. A few examples of equipment types include controls, conductors, insulated transitions, interrupting devices, arresters, structures and supports, switches, and transformers.~~

- b) Lightning—~~The lightning category includes~~ All interruptions caused by lightning, whether ~~This may be~~ by a direct stroke contacting the wires or other ~~another piece of~~ equipment, or by a lightning-induced flashover of the wires or other ~~another piece of~~ equipment.
- c) Planned—Including ~~The planned category includes~~, but ~~is~~ not limited to:— road construction, distribution-line maintenance and repairs, load swaps, and ~~replacing~~ equipment replacements ~~, and house moves~~. Typically, planned interruptions ~~are those interruptions that~~ can be delayed by ~~the~~ utility personnel and performed only after ~~the~~ appropriate or required customer notification. Many ~~Often~~, regulatory commissions have specified rules for ~~describing~~ planned interruptions.
- d) Power supply—Including ~~The power supply category includes~~ interruptions caused by a failure in the power generation or transport system that delivers power to the distribution substation. Traditionally, this category included transmission systems, the bulk electric system (BES) and non-BES ~~transmission system including the transmission~~ portion of a substation, subtransmission, and ~~or~~ the loss of a generating unit. With the advent of distributed energy resources, the "power supply" category can include distributed generation and storage on the utility side of the meter. This category including those associated with distributed generation. It does not include outages resulting from ~~due to~~ the loss of ~~a~~ distribution substation components ~~component~~.
- e) Public—Any interruption ~~interruptions~~ resulting from ~~as~~ an act of the public at large, such as ~~should be put into the public category. Examples include:~~ customer trouble; ~~, nonutility~~ employee or contractor dig-in; ~~, fire/police requests;~~ foreign contact (e.g., such as ~~My~~ Mylar balloon , crane boom, and aluminum ladder); ~~, traffic accidents;~~ vandalism; ~~, and fires, and~~ explosions, and smoke not originating on or within utility-owned equipment.
- f) Vegetation—~~The vegetation category includes~~ Interruptions caused by falling trees or limbs, or growth of trees, vines, and roots. ~~It should be emphasized that~~ If a tree is involved, the cause category is "vegetation." ~~This is important to note during wind storms. It may not be possible to determine that a feeder may have a forestry issue if wind is listed as the cause when actually a tree was involved.~~

- g) Weather—~~The category of weather should include~~ Interruptions resulting due directly or indirectly from ~~to~~ a weather phenomenon such as wind ~~including: wind,~~ snow, ice, hail, ~~and rain,~~ and flooding when ~~where~~ the weather itself caused the interruption by exceeding ~~and exceeded~~ the system's design limits. Wind does not include slapping or galloping conductors, which fall ~~; those would go~~ under the "equipment" category. Ice forming on conductors and tearing them down or flooding of power facilities would be included in the weather category.

~~NOTE—If any part of a tree is involved, it would go under the vegetation category.~~⁵

- h) Wildlife—~~This includes~~ Mammals, birds, reptiles, and insects, or any other nonhuman member of the animal kingdom that causes an interruption ~~. Wildlife can cause interruptions~~ directly through contact, ~~like snakes, mice, ants, raccoons, squirrels, or birds;~~ or indirectly (e.g., like nests or and bird excrement that affect equipment).
- i) Unknown—Any interruption for which ~~The unknown category includes any customer interruptions where~~ a definitive cause cannot be determined after an investigation. The level of investigation required is determined by the individual utility.
- j) Other—Any interruption cause ~~interruptions to customers that is known but does~~ ~~do~~ not fall into any of the previously listed ~~other~~ cause categories, ~~should be assigned to the other category. Some examples include: errors in construction, maintenance, operating, or protecting; overload;~~

4.5 Interruption cause subcategories

The 10 categories of interruption causes discussed in 4.4 are useful for high-level benchmarking. If more detailed benchmarking or analysis is desired, more granular outage cause information is needed. For this purpose, the IEEE Distribution Reliability Working Group developed a set of subcategories (Martino [B4]).

Information from the field after a restoration might be inconclusive so that a subcategory cannot be definitively identified. In these instances, it is acceptable to leave the subcategory blank rather than entering inaccurate data that could negatively impact reliability decision making.

Some utilities may want to only record outages under the "equipment" category or may have regulatory obligations to record causes in a certain way, but additional inputs to the outage record capture detail that is useful for comparing (and improving) reliability. These inputs generally transcribe to the "sustained" or interruption cause, the "initiating" or contributing cause, and the affected equipment. The initiating cause is the event or phenomena that likely led to or contributed to a sustained cause (IEEE 1782 category/subcategory). In general, the initiating cause is the disturbance that changes the electrical system state from static to dynamic and is intended to help explain how the sustained cause led to a customer interruption.

For example, a tree falls on a windy day and contacts the primary overhead wires. In this instance, the initiating cause could be Weather—Wind, the sustained cause could be Vegetation—Tree, and the affected equipment could be Equipment—Conductor/Cable. This example identifies how one outage record could be discernable from another, where the initiating cause distinctly distinguishes the two outage events.

In another example, wind causes galloping on a conductor, resulting in a circuit lockout. The circuit is patrolled with no damage found and the circuit is successfully reenergized. For this example, Weather— Wind is both the initiating and the sustained cause, and the affected equipment could be Equipment— Conductor/Cable. This example is not to infer an initiating cause is required or otherwise necessary to be duplicative of the sustained cause, but instead it highlights how they can both be the same without undermining their combined usefulness.

This subclause identifies the subcategories to the IEEE 1782 categories, while affected equipment and initiating cause inputs to an outage record are covered later in the guide in 4.6 and 4.7.

Table 3 through Table 12 describe the types of interruptions that may be put into each category and subcategory. It is not possible to discuss every type of interruption, but for most interruptions, the choice of category is apparent. The subcategories identify the catalyst for a system interruption that results in customers experiencing a service interruption.

Table 3—Equipment subcategory

IEEE 1782 category	Subcategory
<i>Equipment</i> Any interruption caused by a piece of distribution system equipment that is defective or fails and causes an interruption of service to customers.	<i>Degradation</i> Equipment that has exceeded its designed life span initiates a failure because the equipment can no longer perform as expected.
	<i>Equipment error</i> Equipment does not operate as intended because of its placement, component/control design, or erroneous operation (or mis-operation) in response to faults when no other cause is identified.
	<i>Environmental</i> Equipment fails prior to its expected end of useful life because of manufacturing defect or unexpected environmental intrusion (such as water entering).
	<i>Other</i> Any piece of equipment that is not covered by other items in this subcategory and that fails to operate as expected under reasonable operating conditions. The failure could be a result of wear, fatigue, corrosion, contamination, or long-term exposure to the environment.

(New)

Table 4—Lightning subcategory⁸

IEEE 1782 category	Subcategory
<i>Lightning</i> All interruptions caused by lightning, whether by a direct stroke contacting the wires or other equipment, or by a lightning-induced flashover of the wires or other equipment.	<i>Direct strike</i> A lightning strike makes direct contact with equipment, causing the outage. See NOTE.
	<i>Indirect strike</i> A lightning strike makes contact with the area surrounding equipment, causing protection schemes to operate for reasons including lightning-induced flashover of the wires or other piece of equipment.

(New)

NOTE—A lightning strike would not apply to a failed arrester.

⁸⁵ Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

Table 5—Planned subcategory

IEEE 1782 category	Subcategory
<i>Planned</i> Including, but not limited to, road construction, distribution-line maintenance and repairs, load swaps, and equipment replacements. Typically, planned interruptions can be delayed by utility personnel and performed only after appropriate or required customer notification. Many regulatory commissions have specified rules for planned interruptions.	<i>New construction</i> This subcategory applies to any planned power outage that results from a distribution line needing to be deenergized to accommodate building of new structures. The new construction can be undertaken by the utility, local municipality, or other entity.
	<i>Maintenance</i> This subcategory applies to planned outages resulting from deenergizing a line so that maintenance work can be completed safely.
	<i>Customer request</i> This subcategory applies to outages resulting from a customer request. For example, so that work at the customer's address can be completed safely. An outage of this type can sometimes affect surrounding customers.
	<i>Other utility request</i> This subcategory applies to outages that result from the request of another electric or nonelectric utility.
	<i>Other</i> This subcategory applies to any planned outage that not covered by other definitions in this category.

(New)

Table 6—Power supply subcategory

IEEE 1782 category	Subcategory
<i>Power supply</i> Including interruptions caused by a failure in the power generation or transport system that delivers power to the distribution substation. Traditionally, this category included transmission systems, the BES and non-BES portion of a substation, subtransmission, and the loss of a generating unit. With the advent of distributed energy resources, the "power supply" category can include distributed generation and storage on the utility side of the meter. This category does not include outages resulting from the loss of distribution substation components.	<i>Generation</i> This subcategory applies to a distribution system outage that results from loss of generation that is serving the transmission or distribution system.
	<i>Transmission</i> This subcategory applies to distribution system outages that result from a fault on the transmission system, which includes BES and non-BES infrastructure.
	<i>Subtransmission</i> This subcategory applies to distribution system outages that result from a fault on the subtransmission system.
	<i>Distribution</i> This subcategory applies to distribution system outages that result from a fault on a third-party distribution system, such as a neighboring (or municipal) utility, that supplies a utility distribution system.
	<i>Distributed generation and storage</i> This subcategory applies to interruptions caused by the unintended malfunction of utility- or customer-owned distributed generation and/or storage systems.
	<i>Other utility supply</i> This subcategory applies to outages affecting a distribution customer that is within a utility's service territory but has a distribution feed from a neighboring utility, often referred to as a "borderline" customer.

(New)

Table 7—Public subcategory

IEEE 1782 category	Subcategory
<i>Public</i> Any interruption resulting from an act of the public at large, such as customer trouble; nonutility employee or contractor dig-in; fire/police requests; foreign contact (e.g., Mylar balloon, crane boom, and aluminum ladder); traffic accidents; vandalism; and fires, explosions and smoke not originating on or within utility-owned equipment.	<i>Dig-in</i> This subcategory applies to interruptions that result from a dig-in to distribution underground facilities. A variety of entities can be responsible for a dig-in, including homeowners, subcontractors, third-party contractors, and unknown entities, and causes can include mismarked dig locations or utility facilities.
	<i>Foreign contact</i> This subcategory applies any time a foreign object (not including vegetation or vehicles) contacts the electricity distribution system, causing an interruption in electricity service. Examples of foreign objects that can cause outages include balloons (Mylar or rubber), metal building components, trampolines, and cranes or backhoes.
	<i>Fire/Police</i> This subcategory includes any interruption in electric service resulting from a fire or an explosion. Examples include fires and/or explosions in a manhole; grass, prairie, and forest fires; and explosions at a factory or similar facilities. This category also includes interruptions resulting from fire or police requests to disconnect electrical service because of dangerous or hazardous situations.
	<i>Vehicle</i> This subcategory includes any interruption by vehicle accidents and contact with utility equipment.
	<i>Other</i> This subcategory includes interruptions caused by vandalism, nonutility tree-trimming incidents, and other similar circumstances.

(New)

Table 8—Vegetation subcategory

IEEE 1782 category	Subcategory
Vegetation Interruptions caused by falling trees or limbs or growth of trees, vines, and roots. If a tree is involved, the cause category is “vegetation.”	Within clearance zone (right-of-way) This subcategory applies to outages caused by vegetation that is within the utility’s vegetation clearance zone (right-of-way [ROW]). Specific causes of within clearance zone vegetation caused outages include vegetation growth into conductors, vines within the ROW, and trees or limbs located within the ROW and fall onto distribution system facilities.
	Outside clearance zone This subcategory applies to outages caused by vegetation outside of the utility’s maintained vegetation clearance zone (ROW). Specific causes of outside clearance zone vegetation caused outages include trees and limbs falling onto distribution system facilities.
	Other This subcategory applies to any vegetation caused outage that not covered by other definitions within the vegetation category.

(New)

Table 9—Weather subcategory

IEEE 1782 category	Subcategory
Weather Interruptions resulting directly or indirectly from a weather phenomenon such as wind, snow, ice, hail, rain, and flooding when the weather itself caused the interruption by exceeding the system’s design limits. Wind does not include slapping or galloping conductors, which fall under the “equipment” category. Ice forming on conductors and tearing them down or flooding of power facilities would be included in the weather category.	Precipitation An outage should be categorized as resulting from weather when snow, sleet, or heavy rain causes an interruption to distribution system customers. Outages caused by ice are coded separately.
	Ice This subcategory applies to outages caused by ice buildup on the distribution system.
	Wind This subcategory applies when any of the following phenomena cause an interruption to distribution system customers: tornadoes, hurricanes, and wind gusts strong enough to by themselves damage equipment and thereby cause an interruption.
	Extreme temperature This subcategory applies when the temperature is extreme enough to cause damage to distribution equipment/wires and as a result interrupt electricity service to customers.
	Other This subcategory applies when weather-induced phenomena or natural disasters not listed in the other “weather” subcategories, such as mudslides, floods, and earthquakes, cause interruptions in electricity service to distribution system customers.

(New)

Table 10—Wildlife subcategory

IEEE 1782 category	Subcategory
Wildlife Mammals, birds, reptiles, insects, or any other nonhuman member of the animal kingdom that cause an interruption directly through contact or indirectly (e.g., nests or bird excrement that affect equipment).	Mammal This subcategory applies to outages caused by a mammal's interaction with the electricity distribution system. Squirrels, beavers, raccoons, and rodents are examples of species that cause outages by coming into contact with distribution system infrastructure.
	Bird This subcategory applies to outages caused by a bird's interaction with the electrical distribution system. Specific types of interactions with the system can vary depending on the type of bird, for example, raptors perching. The "bird" subcategory can also include outages resulting from bird nests or bird excrement contacting system infrastructure.
	Reptile/Amphibian This subcategory applies to outages caused by a reptile's or an amphibian's interaction with the electrical distribution system. Species commonly involved in reptile/amphibian outages are snakes, frogs, and lizards.
	Other This subcategory applies to any outage caused by wildlife but not covered by other definitions in this category. Examples of species that fall into the "other" subcategory include insects and fish.

(New)

Table 11—Unknown subcategory

IEEE 1782 category	Subcategory
Unknown Any interruption for which a definitive cause cannot be determined after an investigation. The level of investigation required is determined by the individual utility.	No specific cause found This subcategory applies when the affected line has been patrolled (or evaluated) and a definitive cause cannot be determined.

(New)

Table 12—Other subcategory

IEEE 1782 category	Subcategory
Other Any interruption cause that is known but does not fall into any of the previously listed cause categories.	Utility error This subcategory applies whenever an outage results from an electric utility or its field personnel making a mistake, for example, in areas such as construction, distribution automation, maintenance, operations, or protection.
	Other utility initiated This subcategory applies when another utility ("utility B") causes a loss of service to utility A's distribution customers. Examples include problems with equipment belonging to another electrical or nonelectrical utility (utility B) that is housed on a common structure (or in a shared trench) resulting in an interruption to utility A's customers. See NOTE 1.
	Other This subcategory applies to any outage for which the cause is known but not covered by other definitions in this or any of the other main categories. See NOTE 2.
NOTE 1—Planned outages that are initiated/requested by other utilities should be coded as "Other Utility Request" code within the "Planned" subcategory.	
NOTE 2—Outages where the cause is unknown should be categorized as Unknown—No Specific Cause Found.	

(New)

4.6 Affected equipment

Benchmarking studies frequently examine equipment performance. Equipment is the system component that is usually responsible for a customer interruption. Data collected on affected equipment can be categorized by number of interruption events, number of customers affected, or duration of the interruption. Analysis of this datum may yield rates of failure for various types of equipment, reveal whether some utilities have more of a problem with a particular type of equipment compared to the experience of other utilities, or reveal how the use of equipment varies from one utility to another.

In general, data on affected equipment are intended to supplement the interruption cause categories and subcategories described in 4.4 and 4.5. The combination of information about affected equipment, cause categories and subcategories, and contributory factors (4.7) will generally capture the essence of an outage event.

A list of categories of equipment recommended for tracking is as follows. Some companies have databases that contain this list of equipment for purposes of directly linking assets to outage causes:

- a) Structure/Support
- b) Insulator
- c) Conductor/Cable
- d) Connector/Splice
- e) Elbow/Terminator
- f) Arrester
- g) Transformer
- h) Simple Switching Device

- i) Simple Interrupting Device
- j) Advanced Interrupting/Switching
- k) Controls
- l) Circuit Breaker
- m) Other

Structure/Support refers to noninsulating elements that hold or support conductors or cables, including poles, brackets, and cross arms. These structures can cause an outage by failing to secure a conductor or cable under reasonable operating conditions.

Insulator refers to equipment used to isolate energized conductors or cables from support structures. Insulators can deteriorate from long-term exposure to environmental factors (salt, chemicals, ultraviolet radiation, etc.). An insulator that has a chipped skirt or that breaks can cause tracking or arcing, which, in turn, can cause brittleness, resulting in wires coming down even under normal load/sag.

Conductor/Cable refers to an overhead conductor or underground cable. An overhead conductor can break because of fraying or brittleness resulting from exposure to the environment. An underground cable can short as a result of water intrusion or deterioration of casing or internal insulation.

Connector/Splice refers to any type of connection on an overhead conductor or underground cable that tracks internally as a result of water intrusion or corrosion or that cracks, splits, or develops holes because of exposure to the environment. Examples of connectors include (but are not limited to) automatic splice connections, stirrups, hot line clamps, pad connectors, and piercing style connectors.

Elbow/Terminator refers to equipment that connects a conductor or cable to equipment or to an insulated transition that tracks internally because of corrosion or water intrusion corrosion or that cracks, splits, or develops holes as a result of exposure to the environment.

Arrester refers to a type of surge protection equipment that causes an outage by failing, permanently shorting, tracking, or having damaged/blown parts that contact energized lines.

Transformer refers to a component that transfers electrical energy from a primary distribution circuit to a secondary distribution circuit or to a consumer's service circuit. It can fail because of internal or external breakdowns caused by exposure to the environment, contamination, tracking on bushings, or other factors.

Simple Switching Device refers to a manually operated device that opens or closes circuits. Simple switching devices include motorized, ganged air break switches and gang-operated air break switches. They can cause or extend an outage either by failing to operate or by creating a fault by arcing, tracking, or shorting as a result of rusted, corroded, or worn parts.

Simple Interrupting Device refers to a device such a standard link fuse or nonsettable sectionalizer whose functional specification and operational parameters are set by the manufacturer and cannot be altered by a utility (end user).

Advanced Interrupting/Switching Device refers to a switch that can interrupt current flow and that has functional specifications and operational parameters that are configured by the manufacturer but can be changed by the utility or end user using a program or control selectable interface. Examples include reclosers (hydraulic and electronic), programmable switching devices, and settable sectionalizers.

Controls are equipment, such as a control box, used to operate "smart" devices with programmable logic or remotely through supervisory control and data acquisition (SCADA). Controls can cause or extend an outage by failing or misoperating. Misoperation or failure can result from water intrusion through a worn or missing weather seal, an external case damaged by exposure to the environment, missing or dead battery backup, or frayed or corroded communication wires or connectors.

Circuit Breaker is a mechanical switching device capable of operating (making, carrying, and breaking electrical current) under normal and specified abnormal circuit conditions. Some common causes for circuit breaker failure can include overload, wear, fatigue, corrosion, and contamination.

Other encompasses any piece of equipment not covered by other definitions above, which fails to operate as expected under reasonable operating conditions because of wear, fatigue, corrosion, contamination, or long-term exposure to the environment.

4.7 Contributory factors

In many instances, multiple factors contribute to an outage. Different entities characterize these factors differently; for example, the North American Electric Reliability Corporation (NERC) distinguishes between initiating and sustained causes of an outage. Other organizations or utilities may rely on comments or in-house categorizations to describe causal factors. To help with reducing conflicting definitions among different organizations, an option would be to utilize the concept of a contributory factor. A contributory factor can be thought of as a pre-event that is directly relevant to an outage. Contributory factor categories can be the same as the "primary" cause categories and subcategories described in 4.4 and 4.5. Incorporating contributory factors could allow utilities to preserve information to describe an event beyond the primary categories and subcategories of causes. In some cases, the contributory factor may be treated as the initiating cause or sustained cause, as introduced in 4.5, when appropriate.

Some utilities may also be required by their regulatory agencies or governing bodies to record specific, detailed narratives of operational events and to use outage incidents as the proxy for those events. Those requirements may not align with the recommendations in this guide and/or with how the utility currently reports outage causes. For example, California utilities are required to report specific outages that are considered to pose a risk of igniting fire. Outage cause codes and subcategories were not designed to capture this kind of information, but the category of contributory factors can be used to record these attributes of an event without compromising the use of uniform outage classification categories. Moreover, the information added by recording contributory factors can help with investigations of root causes of outages.

The examples below illustrate how cause categories and subcategories, affected equipment, and contributory factors work together to help codify the cause of an outage. These examples highlight issues that utilities may face in meeting internal and/or external reporting requirements. Certain of these approaches can complicate data mining because key information may not be readily accessible in a standard format; text mining (including potential misspellings) may be the required solution, which could limit the extensibility of the approach and confidence in the findings.

Examples of outage cause classifications using categories, subcategories, and contributory factors:

- A tree felled by a logger. In this scenario, the "sustained" cause category and subcategory could be "Vegetation—Outside Clearance Zone (ROW)," with "Public—Other" as the "initiating" contributory factor. The affected equipment could be "Conductor/Cable." The two causes in this example help to distinguish the outage from other events such as high winds felling a tree from outside the ROW.
- A tree felled by high wind. In this scenario, the "sustained" cause category and subcategory could be "Vegetation—Outside Clearance Zone (ROW)," with "Weather—Wind" as the "initiating" contributory factor. The affected equipment could be "Conductor/Cable." The two causes in this example help to distinguish the outage by making clear that the tree falling was likely a result of wind rather than of other factors.
- A vault floods during a rainstorm. In this scenario, the "sustained" cause category and subcategory could be "Weather—Precipitation," with the addition of "Weather—Other" as the "initiating" contributory factor. The affected equipment could be "Elbow/Terminator." In this example, the two causes help to distinguish the outage from other events such as a water main burst.

- A vault floods after a water main burst. In this scenario, the "sustained" cause category and subcategory could be "Public—Other," with the addition of "Other—Other Utility Initiated" as the "initiating" contributory factor. The affected equipment could be "Elbow/Terminator."
- A fused cutout operates on a hot day with no system overloads or other operations on the same circuit. In this scenario, the "sustained" cause category and subcategory could be "Equipment—Equipment Error," with the addition of "Weather—Extreme Heat" as the "initiating" contributory factor. The affected equipment could be "Simple Interrupting Device." In this example, the two causes help to clarify that the outage may be from equipment overloading (i.e., line current exceeded the continuous rating of a standard overhead fuse).
- A protective device operates on a mild temperature day with high winds. In this scenario, the "sustained" cause category and subcategory could be "Equipment - Equipment Error," with the addition of "Weather - Wind" as the "initiating" contributory factor. No affected equipment was found. A patrol indicated no damage to the system but noted high winds in the area, which indicates that although there is no known cause for the fault, wind is suspected to have initiated the outage.
- A vehicle strikes a pole resulting in a wire down in California. In this scenario, the "sustained" cause category and subcategory could be "Equipment—Other" with the addition of "Public—Other" as the "initiating" contributory factor. The affected equipment could be "Conductor/Cable." Due to California's current reporting requirements, the utility could use additional cause categories and subcategories to describe the outage more explicitly such as "Equipment—Wire Down" and "Public—Car vs. Pole."
- High winds cause conductor slapping. In this scenario, the "sustained" cause category and subcategory could be "Equipment—Environmental," with the addition of "Weather—Wind" as the "initiating" contributory factor. The affected equipment could be "Conductor/Cable."

4.8 Responsible system

The responsible system is the portion of the system in which a fault is initiated. This information is useful in benchmarking studies. There are several categories of responsible system, including the following:

~~When participating in benchmarking studies, it is useful to know the responsible system. This is defined as the portion of the system in which the fault initiated. There are several responsible system categories. These include:~~

- a) Distribution overhead
- b) Distribution underground
- c) Generation
- d) Substation
- e) Transmission

1) Subtransmission—System elements operated at voltages typically between distribution and primary transmission

2) Non-BES-transmission—System elements operated at voltages for primary transmission but not registered with NERC as elements of the BES

3) BES transmission—System elements operated at voltages for primary transmission and registered with NERC as elements of the BES

- f) Customer equipment

The "customer equipment" category refers to customer-owned equipment that is an integral part ~~portion~~ of the utility's system, and that, when a fault occurs on this ~~the customer-owned~~ equipment, ~~it~~ causes interruptions to one or more of the utility's other customers.

4.9 Conditions

The term "categories under conditions" ~~refers~~ refer to circumstances ~~conditions~~ at the time of an ~~the~~ interruption, which can ~~. Many times the condition may~~ be an important ~~a contributing~~ factor in ~~to~~ the number of customers interrupted ~~customer interruptions~~ or the time it takes to restore customers. ~~The~~ Conditions can ~~may~~ play an important role in analysis of ~~when~~ analysing benchmarking data. The following categories are proposed for classifying conditions ~~condition categories include~~:

- a) Routine (day-to-day)
- b) Major event days

"Routine" conditions are typical ~~is defined as~~ daily conditions that do not constitute a major event day. A major event day is defined by IEEE Std 1366. The "conditions" ~~TM in the major event day definition. These~~ designations would have to be added to ~~the~~ interruption data after it is determined ~~the determination~~ that a major event has occurred.

~~Additionally,~~ Individual utilities could ~~may~~ choose to collect data on other conditions, such as weather, that are observed ~~were present~~ during the time of an ~~the~~ interruption ~~event~~. For example, each utility could develop a list of weather conditions based on ~~upon~~ local climate.

4.10 Voltage level

In some benchmarking studies, information is provided using typical voltage classes (phase-to-phase) as shown in the following ~~list below~~. The voltage information for a customer interruption event should be based on the highest voltage level affected~~:~~:

- a) Secondary/Low voltage
- b) 5 kV
- c) 15 kV

- d) 25 kV
- e) 35 kV
- f) >35 kV
- g) Transmission

1) Sub-transmission

2) Non-BES Transmission

3) BES Transmission⁹

4.11 Interrupting devices

Benchmarking studies might ~~may~~ review the type and total number of interrupting devices used, the ~~their~~ failure (misoperations or mechanical failure) rates of interrupting devices, ~~how many~~ operations occurred, and the ~~total~~ number of operations. The interrupting devices deployed. ~~Interrupting~~ device is the device that initiates a ~~the start of the~~ customer interruption. The following is the recommended list of categories for describing ~~of~~ interrupting devices⁹:

⁹ Note that system voltages for BES and non-BES transmission can overlap. That is, although most BES transmission voltages are greater than 100 kV, some BES transmission voltages are less than 100 kV. Similarly, although most non-BES transmission voltages are less than 100 kV, some non-BES transmission voltages are greater than 100 kV. The distinction between BES and non-BES transmission depends on whether a transmission element is registered with NERC as part of the BES.

- a) Circuit breaker/substation recloser
- b) Fuse
- c) Line recloser
- d) Sectionalizer
- e) Switch
- f) Other

The following comments focus discussion-centers on which ~~particular~~ devices should be put into each of the above categories, with the caveat that category. ~~Of course,~~ not every possible device can be discussed. The circuit breaker/recloser category should include circuit breakers and reclosers found in substations and those used for protection of entire feeders/lines. The fuse category should include line, tap, and transformer fuses. Line recloser devices are ~~Reclosers~~ located along a circuit/line and can ~~should~~ be programmed to open and close automatically in an attempt to restore service by clearing transient faults. Hydraulic reclosers, electronic reclosers, cut-out mounted reclosers, and pulse closing devices are examples of ~~the~~ line reclosing devices ~~recloser category.~~ Gang switches and blade disconnects belong ~~are-captured~~ in the switch category. Any other interrupting devices not covered by the first five categories, including ~~an~~ open conductors, fall into ~~conductor, are grouped under~~ the "other" category.

4.12 Interrupting device initiation

~~Another~~ Analysis of interrupting devices may include the manner in which they operated when they were opened and closed. ~~These~~ Operations can be classified ~~fall~~ into two ~~the following~~ recommended categories:

- a) Automatic
- b) Manual

"Automatic" includes all operations that take place without human intervention. "Manual" includes all operations ~~is any operation~~ that involve ~~involves~~ personnel controlling ~~to operate~~ the device, whether at the location of the device or from a remote location.

4.13 Customer restoration

Benchmarking studies may analyze how customers' power is ~~are~~ restored after ~~experiencing~~ an interruption. Customers' premises can ~~to power. There may~~ be re-energized in several ways following ~~to reenergize customers after~~ an interruption. The suggested categories of restoration are as follows:

- a) Automatic substation transfer
- b) Automatic circuit sectionalizing
- c) Manual circuit sectionalizing
- d) Left disconnected
- e) Re-energized at station
- f) Grid separation
- g) Temporary installation
- h) ~~Repaired~~ Defective equipment repair
- i) Defective equipment replacement
- j) Fuse replacement
- k) Transformer breaker reset
- g) ~~Replaced defective equipment~~
- h) ~~Replaced fuse~~

i) ~~Reset transformer breaker~~

j) ~~Installed temporary~~

The first category, "automatic substation transfer," includes any scheme that shifts ~~transfers~~ customers to an alternate supply when ~~in the event that~~ their primary supply is interrupted. This scheme operates without ~~any~~ human intervention.

"Automatic circuit sectionalizing" refers to any automatic schemes outside the substation that transfer customers experiencing a power interruption to another energized circuit segment, either on the same circuit or a different circuit.

"Manual circuit sectionalizing" refers to any action taken by field personnel or remote operation by an operations supervisor to transfer interrupted customers to other feeders/circuits. This also includes resetting midline reclosers and operating switches to re-energize interrupted customers using ~~to~~ another part of the same feeder/circuit.

In some cases, customers will not be put back in service, for example, because of a ~~due to fire, flood, or some other destructive~~ force such as fire or flood that destroys the customer premises entity requiring power. In this case, "left disconnected" is the category.

Sometimes a feeder/circuit is not able to restore customers after fault operation(s) (resulting in a lock- locked-out) at the station with ~~and~~ no cause ~~is~~ found. In that situation, the circuit breaker or recloser is closed again (reclosed), and, if it holds, the category "re-energized at station" applies. This approach ~~is chosen. It~~ may also be used for transformer or bus outages in the station.

"Grid separation" describes a situation in which a customer disconnects from the grid during an outage and utilizes off-grid power from a distributed energy resource (DER) such as a microgrid or some other form of electric generation.

"Installed temporary" describes a situation in which a utility makes a temporary repair to restore service or maintain public safety until a permanent repair can be made (State of New York Public Service Commission [B7]). Examples include a temporary repair to restore customers after an interruption caused by a vehicle accident or a storm when permanent repairs cannot be made immediately.

The last four ~~five~~ categories, "defective equipment repair," "defective equipment replacement," "fuse replacement," and "transformer breaker reset," are self-explanatory.

~~3.11 Equipment failure or deterioration~~

~~Benchmarking studies frequently examine equipment performance as well. This equipment is usually failed equipment that initiated the customer interruption. Typically, pieces of equipment are grouped into different categories. Data collected may be by number of interruption events, number of customers affected, or by duration of the interruption. Results from this data may reveal rates of failure for various types of equipment, if some utilities have a problem with a type of equipment as compared to other utilities, and how the use of equipment varies from one utility to another. The following is the recommended list of categories of equipment.~~

- ~~a) Cable~~
- ~~b) Wire~~
- ~~c) Connector~~
- ~~d) Control~~
- ~~e) Insulated transition~~
- ~~f) Interrupting device~~
- ~~g) Lightning/surge arrester~~
- ~~h) Other equipment~~

i) ~~Structural support~~

j) ~~Switch~~

k) ~~Transformer~~

~~The “cable” category includes all cable that is direct buried or placed in pipe or conduit or U guard. “Wire” refers to overhead strung conductors and jumpers. Connections, splices, and other hardware are not included in these two categories. The “connector” category includes connectors, insulinks, splices, etc. The “control” category contains relays, smart meters, and other control equipment. “Insulated transition” is comprised of bushings, insulators, separable connectors, polymeric terminations, potheads, stress relief cones, etc. The “interrupting device” category consists of circuit breakers, reclosers, and fused equipment. The “lightning/surge arrester” and “other” categories are self-explanatory. “Structural support” category includes anchors, poles, towers, cross arms, braces, etc. The “switch” category contains disconnect, isolation, and load break switches; solid blade cutouts; etc. The last category, “transformer,” can include auxiliary, current, distribution, grounding, potential or voltage, power, rectifying, step-down/conversion, and voltage regulating transformers.~~

5. Data collection within the electric power distribution industry

5.1 Overview

It is generally accepted that in today's operating environment, utilities need to accurately capture information regarding the number of service interruptions, their duration, and the number of customers affected (Robinson et al. [B5 B2]). Most utilities, including investor-owned, municipal, and cooperative ~~entities~~ ~~utilities~~, have realized the need to ~~document~~ ~~capture~~ equipment outages and the resulting customer interruptions; nearly all capture sustained interruptions. The methods and approaches vary widely depending on the existence and sophistication of ~~installed~~ information systems, such as the customer information system (CIS), ~~the~~ geographic information system (GIS), ~~SCADA~~ ~~the supervisory control and data acquisition~~ system ~~(SCADA)~~, and ~~the~~ outage management system (OMS). In general, a utility's interruption reporting system uses key information from these ~~other~~ systems to ~~document complete, accurate~~ ~~improve the completeness and accuracy of~~ reliability information.

Comparing reliability statistics among ~~between~~ utilities is ~~a difficult~~ for task because of so many reasons, including ~~factors, not the least of which is~~ differing data collection processes and procedures. During ~~the benchmarking process, it is imperative that~~ consideration should be given to the level of data collection at each entity as well as to ~~and~~ the state of implementation of data collection ~~these~~ systems and their associated processes. Even among utilities that have similar systems, such as OMSs ~~an outage management system~~ from the same ~~a specific~~ vendor, performance differences are likely, ~~to occur, due~~ either because of ~~to~~ customization for an individual utility ~~and/or~~ because of process differences ~~that, and those differences~~ may be significant. If these differences are not taken into account, an exact ~~Without such consideration,~~ comparison of different utilities' performance will not be possible ~~inexact~~.

5.2 Manual collection systems

Typically, a utility with paper maps and little or no connectivity ~~records~~ will utilize a fully manual collection approach. Field personnel estimate the number of customers affected during a service interruption. Utilities couple these estimates with an estimate of the start ~~beginning~~ time of the ~~service~~ interruption to determine the impact of each event on customers. This approach may be the least accurate ~~approach~~ of the methods that will be discussed in this guide ~~and~~. It is where ~~the one that forms the starting point for~~ most utilities start ~~in~~ their journey ~~toward~~ evolution to a fully connected system, ~~as~~ Most utilities began collecting reliability performance information as a consequence of building a system to speed up ~~assist with quicker~~ power restoration.

The data collected help the ~~with these systems helps that~~ utility identify and track areas on the system ~~systems~~ that raise ~~have~~ reliability concerns. These concerns could include repeated interruptions and potentially poor customer satisfaction. Generally, a ~~the~~ manual reporting system tracks only sustained interruptions and does not record ~~the~~ momentary interruptions. With manual data collection, it is difficult to properly track ~~In utilizing this method,~~ step restoration efforts and therefore the CMI might not be recorded accurately ~~are very difficult to track properly; specifically the customer minutes of interruption are not reduced correctly~~.