



Electric Utility Distribution Reliability Management

An Online Continuing Education Course for Engineers

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Electric Utility Distribution Reliability Management

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Introduction

The United States has one of the most robust and reliable electric grids in the world and electric customers in the United States can expect to experience less than two outages per year for a total outage time of slightly less than two hours out of an 8,760 hour year.

The reliability of the electric system is an important factor in maintaining a healthy economy, as well as a high degree of customer satisfaction.

In recent years, many consumer advocates and regulatory bodies have expressed concern that the reliability of the electric delivery system is being compromised due to an increased focus on competition and profitability. Many states have passed, or are in the process of passing legislation and/or approving regulations intended to refocus attention on maintaining and improving reliability. As time goes on, these laws and/or rules are expected to become more structured and pervasive.

The reliability of the electric system is affected by all three components of the electric system—generation, transmission, and distribution. Generation reliability is ensured by, among other things, maintaining adequate planning and operating reserves. With a few notable exceptions, the establishment and enforcement of specific reserve requirements by regional reliability councils and power pools has resulted in fewer service interruptions due to the lack of generation capacity. As a result, most service interruptions experienced by end-use customers are the result of interruptions of transmission and distribution (T&D) facilities, not production facilities. Of these delivery system interruptions, the majority of interruptions are generally the result of interruptions of distribution facilities.

One ingredient in maintaining and improving reliability is the development of a consistent set of reliability indices that may be used to measure, report and compare reliability. To date, most industry effort in this regard has addressed the measuring and indexing of total system reliability. The Institute of Electrical and Electronic Engineers (IEEE), for example, has developed a reliability guideline (IEEE1366) that standardizes the calculation of reliability indices for electric utility systems.

The course explains how electric system reliability is measured at the distribution level and describes ways that utilities may increase system reliability. First, we need to define electric system reliability and for that, let's look at Chapter 1.

Chapter 1 - Distribution Reliability

Electric distribution reliability in the United States has remained fairly consistent over the past 10 years in spite of significant programs to improve reliability. Some studies have shown that electric systems are more reliable now however more extreme weather, as well as better reporting, has increased the outage numbers. So while it appears that electric reliability hasn't changed much, many experts agree that reliability is improving.

Approximately 88% of all customer interruptions occur on the electric distribution network with substations the next largest cause (6%), transmission (4%), and generation at only 2%. See Figure 1 below.

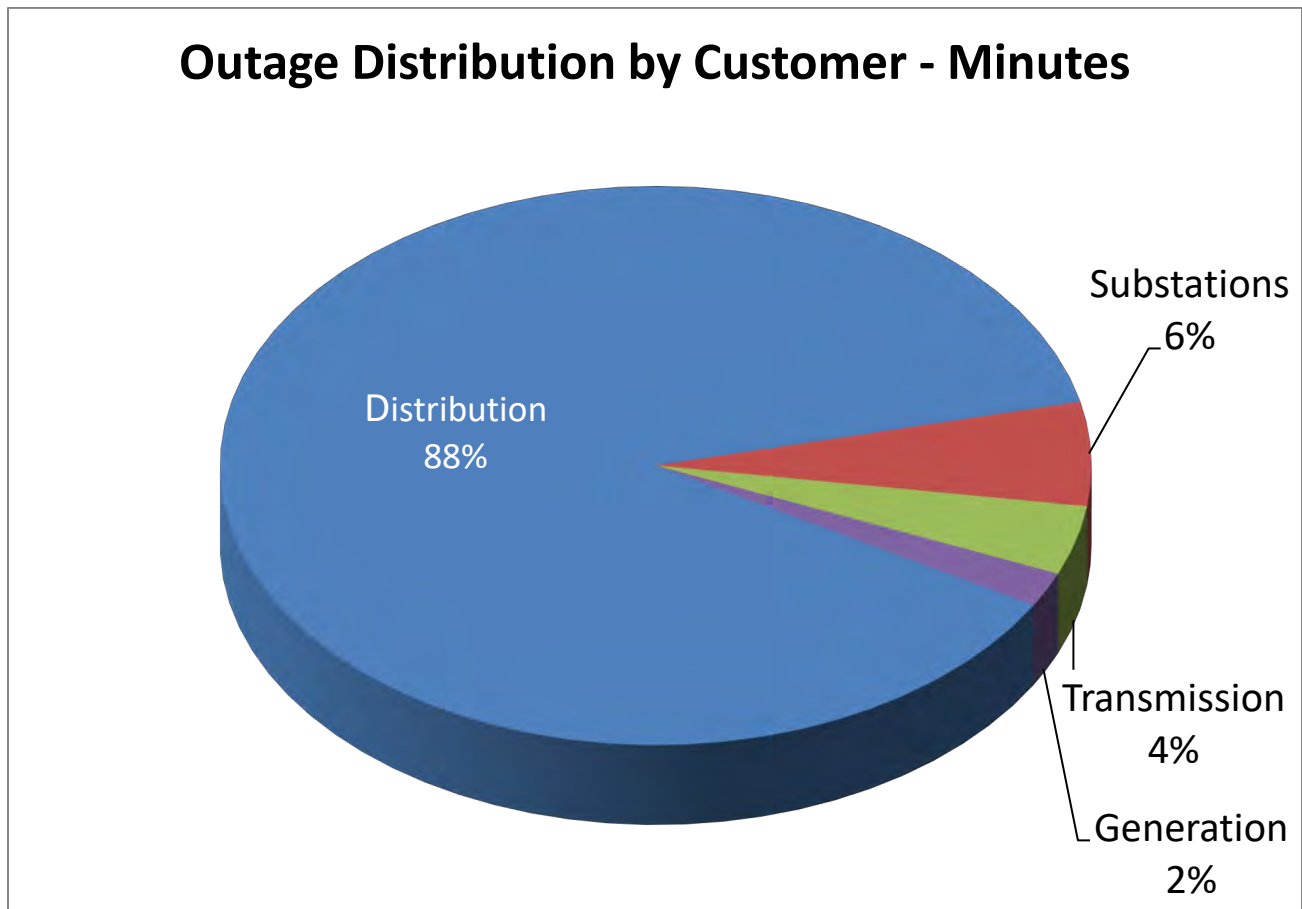


Figure 1

This is a clear indication of the primary importance of distribution system reliability to the reliability of the customers' electric power service: inability to provide service at individual load points arises mainly from distribution system equipment outages.

This chapter defines some of the key terms used in electric system reliability including a definition of electric system reliability. Of course, reliability depends on your perspective as either the end user or the utility itself.

The appropriate definitions of reliability may vary with respect to the perspective taken of the system. Arguably the most important perspective is how the customer views reliability. The occurrence of an outage indicates to the customer that *service reliability* is not perfect. That is, service reliability measures the degree to which customers experience service outages. The words "outage" and "interruption" are frequently used interchangeably but often mean separate things. The important distinction is between equipment outages, as observed by operators, and interruptions of service to the customer. Clearly, an equipment outage may not cause a service interruption; planned maintenance is an example of such an equipment outage, and therefore is not considered to be an outage by the customer – unless the customer is indeed without power.

In addition to its obvious consequences to customers, poor service reliability raises public concern with respect to noneconomic attributes such as health where lack of power for oxygen machines, air-conditioning, and heat may create health risks. Reliability concerns of customers depend on their end-use patterns. Research indicates that customers associate service reliability with restoration time and how accessible and responsive the utility is during interruptions.

The utility perspective may differ from the customer perspective. The definition of reliability for the utility should be related to that of the customer (i.e., service reliability.) Indeed, most utilities define reliability as service reliability, which is the reliability on the service side of customer load points, rather than supply reliability. The supply side of customer load points includes not only distribution equipment but also generation and transmission system assets and performance. Reliability on the supply side of customer load points is determined by the availability of utility equipment. Clearly, the availability of equipment in the distribution, transmission, and generation subsystems is related to service reliability, but equipment outages do not correspond directly to loss of continuity of service since customers can be served by alternate supply assets.

It is also important to note that the maintenance policies adopted by utilities may reflect different perspectives on reliability. A utility that is focused on customer interruptions--*service reliability*- will adopt such policies as Reliability Centered Maintenance (RCM), which is driven by concerns about the effects of customer interruptions. A utility that is focused on *supply reliability*, with particular attention to distribution system equipment, will adopt maintenance policies that are driven by equipment availability criteria that may be set without regard to customer values or needs.

Reliability Definition

There are many different definitions of reliability though they all address some common aspects of electric power systems. These include factors such as:

- Continuity of service
- Meeting customer demands
- Vulnerability of the power system

Reliability concerns are often split into three categories: *adequacy*, or the capacity and energy to meet demand; *security*, or the ability to withstand disturbances; and *quality*, or acceptable frequency, voltage, and harmonic characteristics.

Reliability is commonly defined as:

The degree of performance of the elements of the electric system that results in electricity being delivered to customers within accepted standards and in the amount desired.

Reliability may be measured by the *frequency*, *duration*, and *magnitude* of adverse effects on the electric supply. Electric system reliability can be addressed by considering two basic and functional aspects of the electric system: *adequacy* and *security*.

- *Adequacy* is the ability of the electric system to supply the aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.
- *Security* is the ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system elements.

Similarly, one may define reliability as the system's ability to provide an acceptable level of continuity and quality or a reasonable assurance of continuity and quality.

Other Defined Terms

The following terms are used in this course as defined below.

Adequacy: The ability of the electric system to supply the aggregate electrical demand and energy requirements of the customers at all times.

Distribution: All utility equipment of 35 kV and below.

Instantaneous Interruption: An interruption restored immediately by completely automatic equipment or a transient fault that causes no reaction by protective equipment. Typically less than 15 seconds.

Interruption: Cessation of electric service; lack of availability.

Least-Cost Planning: Attempt to find minimum cost over a wide range of supply options for a given level of service.

Major event day: As defined by IEEE Standard 1366, a day in which the daily SAIDI exceeds a threshold value, T_{MED} . For the purpose of calculating daily system SAIDI, any interruption that spans multiple calendar days is accrued to the day on which the interruption began. Statistically, days having a daily system SAIDI $> T_{MED}$ are days when the energy delivery system experiences stress—such as severe weather. Activities that occur on these days are reported separately.

Major event: An event that causes a major interruption of electric service, such as a major switch failure, automatic, supervisory, or manual interruption, or a major equipment failure. Usually less than three minutes.

Outage: A period of time during which the electric system is unable to perform its intended function, either the first customer call or the first SCADA report.

Permanent: An interruption of electric service by the utility.

Planned: An interruption of electric service by the utility, such as a planned maintenance activity, to allow the distribution system to safely perform routine maintenance.

Power: The rate at which energy is transferred by an alternating current (AC) system. The voltage and current in an alternating system are in step with one another.

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