



# IEEE Recommended Practice for Risk Identification and Evaluation of Smart Power Distribution System

IEEE Power and Energy Society

Developed by the  
Transmission and Distribution Committee

IEEE Std 2749™-2023

**STANDARDS**

# IEEE Recommended Practice for Risk Identification and Evaluation of Smart Power Distribution System

Developed by the

**Transmission and Distribution Committee**  
of the  
**IEEE Power and Energy Society**

Approved 30 March 2023

**IEEE SA Standards Board**

**Abstract:** The risk factors that should be considered for the planning, operation, and maintenance of the distribution network are presented in this recommended practice. The approaches and practices for risk identification and evaluation, including the identification of risk factors and events, classification of risk types, evaluation of equipment and network risks, as well as the grading, warning, prevention measures, dynamic tracking, and simulation of risks are also provided. This recommended practice can be applied to the operation risk evaluation and guides the planning, construction, and maintenance of conventional power systems, microgrids, and smart distribution networks with high penetration of distributed energy resources (DER), and flexible loads.

**Keywords:** distribution network, IEEE 2749™, proactive defense, risk identification, risk simulation, risk warning

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The Institute of Electrical and Electronics Engineers, Inc.  
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PDF: ISBN 978-1-5044-9798-5 STD26227  
Print: ISBN 978-1-5044-9799-2 STDPD26227

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## Introduction

This introduction is not part of IEEE Std 2749-2023, IEEE Recommended Practice for Risk Identification and Evaluation of Smart Power Distribution System.

With the rapid development of the smart grid, especially the large-scale integration of distributed energy resources (DER) and flexible loads, the power distribution system is experiencing great changes. The deterioration and failure risks of distribution networks are increasing dramatically, which calls for innovative technologies of risk identification and evaluation. This recommended practice focuses on the risk factors that should be considered in the planning, operation, and maintenance of the distribution network. It also provides the approaches and good practices for risk identification and evaluation, including the identification of risk factors and events, classification of risk types, evaluation of equipment, and network risks, the grading, warning, prevention measures, dynamic tracking, and simulation of risks. This recommended practice will help the distribution network evolve to be more adaptive to new business and operating environments, in the stages of planning, construction, operation, and maintenance, thus enhancing the safe, reliable, and economic operation of distribution networks, advancing the deployment of DER, promoting the development of relevant industries, and facilitating technological progress in risk identification and evaluation.

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# IEEE Recommended Practice for Risk Identification and Evaluation of Smart Power Distribution System

## 1. Overview

### 1.1 Scope

This recommended practice focuses on the factors that should be considered for planning, operating, and maintaining distribution networks such as risk factors and event identification, classification of risk types, equipment and network risk evaluation, risk grade classification, risk early-warning, risk prevention control, risk dynamic tracking, and risk simulation. This recommended practice not only applies to operations risk evaluation but also provides guidance toward the planning, construction, and maintenance of traditional distribution power system, micro-grid systems, and smart distribution networks with access to large-scale distributed energy resources (DER) and flexible loads.

### 1.2 Purpose

This recommended practice identifies and assesses risks and provides technical guidance and methods for smart distribution networks in the planning and operation stages. The implementation of this recommended practice will provide support for improving planning and construction plans and changing the operation mode to enhance the safe, reliable, and economic operation of distribution networks, advance the use of distributed generations, and promote the development of relevant industries and the technological progress of risk identification and evaluation.

### 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*).<sup>6,7</sup>

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 (*may 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*).

<sup>6</sup>The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

<sup>7</sup>The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.

## 1.4 Limitations

This practice applies to operations in risk identification and the evaluation of primary equipment, feeders and the whole distribution network of traditional power distribution networks and power distribution networks with lots of distributed generations and flexible loads accessing.

This practice does not apply to the identification and evaluation of operation risks caused by extreme natural disasters such as earthquakes, typhoons, tsunamis, etc. and artificial destruction such as construction, theft, traffic accidents, etc. The information network security risks and management risks of distribution power systems are not covered in this practice.

## 1.5 Technology status and schema

The power distribution system plays a critical role in delivering a high-quality, efficient, safe, and reliable power supply services. As the final customer-facing stage, the distribution system features a complex structure. Many human and non-human factors may impact the power supply, including equipment failures, protection and control system failures, communication system faults, grid topology changes, natural disasters, meteorological conditions, manual mal-operations, sabotage, external force damages, animal damages, and so on. Many of these risks have distinct random features, making them difficult to predict accurately and may lead to area, or even large-scale, blackouts.

In recent years, the growing penetrations of DER and flexible loads, and the increasing deployment of information and intelligent technologies, have greatly changed the operation situation of distribution systems. These advancements have also aggravated challenges, such as power quality issues, cybersecurity, and other operational risks, which endanger the distribution systems and limit renewable energy consumption.

Adapting to the new changes, distribution systems call for more accurate risk analysis, enhanced by optimized use of all kinds of resources, to provide scientific risk evaluation and warning. This empowers the distribution system with proactive defense, compared to traditional passive processing, to deliver reliable, high-quality services.

This recommended practice helps enable multidimension and multifaceted perception and management of distribution systems risks by providing application guidance from aspects of risk identification, evaluation, warning, and simulation:

- a) Risk identification provides a reference basis for initiating risk evaluation through the following steps:
  - 1) Acquiring mass real-time and historical data of electrical and non-electrical quantities
  - 2) Extracting key features that identify abnormal situations and variation trends
  - 3) Discovering abnormal operation phenomena of the equipment and system
- b) Risk evaluation provides comprehensive risk evaluation for distribution systems on the basis of the following:
  - 1) Identification of abnormal operation of equipment and the whole system
  - 2) Actual operation requirements of the distribution system
  - 3) Statistics, calculation, and analysis of component failure rates
  - 4) Grid topology and connectivity analysis
  - 5) Assessment of the risk probability and consequences on levels of node, feeder, and system

- c) Risk warning issues timely risk warning information and provides reference for developing prevention and control measures, specifically as follows:
  - 1) Determining warning information based on risk evaluation results
  - 2) Following the recommended warning protocol
  - 3) Issuing timely risk warning information
  - 4) Informing parties including operation and maintenance departments and customers
  - 5) Providing references for predicting system operation status trends and formulating relevant prevention and control measures
- d) Risk simulation provides simulation methods and platforms for risk evaluation, specifically as follows:
  - 1) Simulating the occurrence, development, and evolution mechanisms of the operation risks of distribution systems
  - 2) Modifying and verifying modeling methods for risk identification and features extraction
  - 3) Providing a simulation environment and test platform closer to the actual operation for the verification of risk evaluation algorithms at different levels and time scales

## 2. Definitions, acronyms, and abbreviations

### 2.1 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.<sup>8</sup>

**distribution system:** The portion of an electric power system that delivers electric energy from transformation points on the transmission system to the customer. See IEEE Std 1366-2012.

**risk:** The combined impact of the probability of an event occurring and the consequences of that event when it occurs. See IEEE Std C37.10.1-2018.

**risk evaluation:** A procedure based on the risk analysis to determine whether the tolerable risk has been achieved. See ISO/IEC Guide 51:1999.

**risk identification:** The systematic use of available information to identify hazards. See ISO/IEC Guide 51:1999, 3.10.

**risk prevention:** A method to reduce the probability of risk occurrence and risk hazards by choosing an optimal control plan based on risk identification and evaluation.

**risk source:** The factors that can cause risk individually or in combination.

**risk simulation:** A process of constructing risk models and performing risk calculations based on simulation algorithms.

**risk warning:** A way to send information that contains emergency signals and risk situation to report consequences and possibilities of operational risks.

**smart distribution:** The integration of power measurements, two-way communications, analytical decision making, and supervision to execute decisions to improve the delivery of electric energy. See IEEE Std 1854-2019 [B12].

<sup>8</sup>*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.

## 2.2 Acronyms and abbreviations

|       |                                          |
|-------|------------------------------------------|
| AMI   | advanced metering infrastructure         |
| AR    | adjusted rank                            |
| DER   | distributed energy resources             |
| GIS   | geographic information system            |
| PDF   | probability density function             |
| RR    | reverse rank                             |
| SCADA | supervisory control and data acquisition |

## 3. Risk identification

### 3.1 Purpose of risk identification

Risk identification discovers the key characteristics and critical paths of risk occurrence, including the cause of the risk, location of the risk source, duration of the abnormal situation, and changing trend of the abnormal situation. Risk identification provides indicators and criteria for initiating the risk evaluation procedure, which will provide references for subsequent risk prevention and control (See E.1).

### 3.2 Content of risk identification

Risk identification in this practice mainly covers equipment- and system-level risks and includes the following:

- Obtaining and analyzing the large amount of electrical and non-electrical information based on advanced metering infrastructure (AMI), supervisory control and data acquisition (SCADA), etc. in a smart power distribution system
- Identifying the changing trends of key characteristic parameters during risk occurrence and evolution
- Classifying and quantifying each influencing factor, establishing correlation analysis models, developing the risk identification indicators, and proposing criteria for provoking risk evaluation.

### 3.3 Method of risk identification

#### 3.3.1 Equipment-level risk identification

##### 3.3.1.1 Methods and contents

Equipment-level risk identification mainly manifests the current risk and health status of the equipment by collecting and processing various technical indicators, performance, and conditions of the operating equipment. It mainly applies to the primary distribution equipment, including distribution transformers, switchgear, overhead lines, cables, and power electronic devices such as DER.

Equipment-level risk identification mainly includes steps and contents as follows:

- Data collection:* Collected data includes test data, defects and hidden trouble data, online monitoring data, poor operation conditions (over-temperature, overload, short circuit impact, etc.), familial defects, and other failure status data.
- Data Cleaning and Preparation:* Preprocessing of data is required to improve the effectiveness.