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# IEEE Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems

## IEEE Standards Coordinating Committee 21

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**IEEE Standards Coordinating Committee 21 on**
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# IEEE Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems

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**Abstract:** Alternative approaches and good practices for the design, operation, and integration of distributed resource (DR) island systems with electric power systems (EPS) are provided. This includes the ability to separate from and reconnect to part of the area EPS while providing power to the islanded EPSs. This guide includes the DRs, interconnection systems, and participating EPSs.
**Keywords:** circuit island, distributed resources, DR island systems, electric power systems, IEEE 1547.4, intentional island, interconnection, lateral island, microgrid, secondary island, substation bus island

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## Introduction

This introduction is not part of IEEE Std 1547.4-2011, IEEE Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems.

IEEE Std 1547.4 is part of the IEEE 1547™ series of standards. The IEEE 1547 series of standards was created to develop a national consensus on using distributed resources (DR) in electric power systems (EPSs). IEEE Std 1547.4 was specifically developed to address the lack of information included in IEEE Std 1547-2003 regarding intentional islands.[a] This document covers intentional islands in electric power systems (EPSs) that contain DRs. IEEE created a new term *DR island systems* to generically refer to all intentional island systems that could include local and/or area EPS. The term DR island systems, sometimes referred to as *microgrids,* is used for these intentional islands. DR island systems are EPSs that: (1) have DR and load, (2) have the ability to disconnect from and parallel with the area EPS, (3) include the local EPS and may include portions of the area EPS, and (4) are intentionally planned. DR island systems can be either local EPS islands or area EPS islands.

DR island systems offer many potential benefits. They can:

— Improve reliability by providing the islanded portion of the EPS power during an area EPS outage or disturbance.

— Relieve area EPS overload problems by allowing a part of the EPS to intentionally island and removing load from the rest of the area EPS. The benefit is for both island and normal parallel operation.

— Isolate from area EPS power quality issues (voltage distortion, voltage sag, flicker, lightning transients, etc.) while in island mode operation.

— Resolve power-quality issues by reducing total harmonic distortion (THD) at the loads.

— Allow for maintenance on the area EPS while allowing intentionally islanded customers to remain powered.

This document contains several clauses that address various aspects of DR island systems. Clause 3 gives a list of definitions and acronyms used in the document. Clause 4 gives an overview of the general considerations for design and operation of DR island systems and describes the various types of DR island systems. This clause also discusses the modes of operation of the DR island systems, including normal parallel mode, transition-to-island mode, island mode, and reconnection mode. Clause 5 explains the planning and engineering of DR island systems with detailed discussions about the considerations and solutions. Clause 6 describes the operations of the DR island system.

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## 1. Overview

This document covers intentional islands in electric power systems (EPSs) that contain distributed resources (DRs). The term *DR island systems,* sometimes referred to as *microgrids,* is used for these intentional islands. DR island systems are EPSs that: (1) have DR and load, (2) have the ability to disconnect from and parallel with the area EPS, (3) include the local EPS and may include portions of the area EPS, and (4) are intentionally planned. DR island systems can be either local EPS islands or area EPS islands. This document addresses issues associated with DR island systems on both local and area islanded EPSs. It provides an introduction and overview and addresses engineering concerns related to DR island systems.

### 1.1 Scope

This document provides alternative approaches and good practices for the design, operation, and integration of DR island systems with EPS. This includes the ability to separate from and reconnect to part of the area EPS while providing power to the islanded EPSs. This guide includes the DRs, interconnection systems, and participating EPSs.


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## 1.2 Purpose

This guide is intended to be used by EPS designers, operators, system integrators, and equipment manufacturers. The document is intended to provide an introductory overview and address engineering concerns of DR island systems. It is relevant to the design, operation, and integration of DR island systems. Implementation of this guide will expand the benefits of using DR by targeting improved reliability and build upon the interconnection requirements of IEEE Std 1547™-2008.[1]

## 1.3 Limitations

This document also has the following limitation to its use:

— This guide does not establish DR reserve levels for a specific planned island.

— This guide does not address DR island systems on distribution secondary networks.

— The aggregate generating capacity within the DR island system is not restricted by this document.

— Each individual point of common coupling (PCC) is limited to 10 MVA of generation (per IEEE Std 1547-2003).

— This guide does not presume that an area EPS operator desires to establish planned islands on any portion of the area EPS that is normally connected to the balance of the area EPS.

— This guide does not presume that all DR located within an area EPS operator's planned island are participating.

— This guide does not presume that all load located within an area EPS operator's planned island are participating.

— This guide does not provide operational procedures for establishing and operating a planned island.

— This guide does not cover all possible contingencies (e.g., loss of control communications back to the area EPS) that may result in the cessation of planned island operations.

— This guide does not address physical security or cybersecurity.

— This guide does not cover contractual or regulatory considerations.

— This guide does not cover metering, which may be a contractual or regulatory consideration.

# 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.

ANSI/NEMA C84.1-2006, American National Standard for Electric Power Systems and Equipment—Voltage Ratings (60 Hertz).[2, 3]

ANSI/NEMA MG 1-2006, Motors and Generators.

[1] Information on references can be found in Clause 2.
[2] ANSI publications are available from the Customer Service Department, American National Standards Institute, 25 W. 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).
[3] NEMA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (http://global.ihs.com/).


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IEEE Std 399™-1997, IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis *(IEEE Brown Book™)*. [4, 5]

IEEE Std 446™, IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications *(IEEE Orange Book™)*.

IEEE Std 519™, IEEE Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.

IEEE Std 1100™, IEEE Recommended Practice for Powering and Grounding Electronic Equipment *(IEEE Emerald Book™)*.

IEEE Std 1547™-2003 (Reaff 2008), IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems.

IEEE Std 1547.2™, IEEE Application Guide for IEEE Std 1547™ Interconnecting Distributed Resources with Electric Power Systems.

IEEE Std 1547.3™-2007, IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems.

# 3. Definitions, acronyms, and abbreviations

## 3.1 Definitions

For the purposes of this document, the following terms and definitions apply. *The IEEE Standards Dictionary: Glossary of Terms & Definitions* should be referenced for terms not defined in this clause.[6]

**black start:** The ability to start local generation with no external source of power.

**distributed resources (DR):** Sources of electric power that are not directly connected to a bulk power transmission system. DR includes both generators and energy storage technologies.

**distributed resources (DR) island system:** DR island systems are parts of electric power systems (EPSs) that have DR and load, have the ability to disconnect from and parallel with the EPS, include the local EPS and may include portions of the area EPS, and are intentional and planned.

NOTE—Types of DR island systems include: local EPS island (facility island); circuit lateral island; distribution circuit island; substation bus island; substation island; adjacent circuit island.[7]

**distribution system:** That portion of an electric system that delivers electric energy from transformation points on the transmission or bulk power system to consumers.

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**island interconnection device (IID):** A device that allows separation of a distributed resources (DR) island system from the electric power system (EPS). This device may provide the function of a normal paralleling device to reconnect the DR island system with the Area EPS.

**non-participating distributed resources (DR):** Distributed resources that are in the DR island system but are not under control of DR island system operations.

**paralleling device:** A device (e.g., a circuit breaker or switch) that operates under the control of a synchronizing function (manual or automatic) to electrically connect two energized power sources.

**participating distributed resources (DR):** DR that are in the DR island system and are under control of DR island system operations.

**point of distributed resources connection (point of DR connection):** The point at which a DR unit is electrically connected in an electric power system (EPS).

**scheduled transitions:** Intentional events for which the time and duration of the planned island are agreed upon by all parties involved.

## 3.2 Acronyms and abbreviations

| | |
|---|---|
| ac | alternating current |
| ANSI | American National Standards Institute |
| CT | current transformer |
| dc | direct current |
| DR | distributed resources |
| EPS | electric power system |
| IEEE | Institute of Electrical and Electronics Engineers |
| FERC | Federal Energy Regulatory Commission |
| IA | interconnection agreements |
| IID | island interconnection device |
| LGIP | Large Generator Interconnection Procedure |
| LVRT | low-voltage ride-through |
| MIC | monitoring, information exchange, and control |
| NEMA | National Electric Manufacturers Association |
| NERC | North America Electric Reliability Corporation |
| PCC | point of common coupling |
| PID | proportional, integral, derivative |
| SCADA | supervisory control and data acquisition |
| SLTG | single line to ground |
| SGIP | Small Generator Interconnection Procedure |
| var | volt-ampere reactive |


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# 4. DR island systems overview

This clause gives an overview of the general considerations for design and operation of DR island systems and describes the various types of DR island systems. This clause also discusses the modes of operation of the DR island systems, including normal parallel mode, transition-to-island mode, island mode, and reconnection mode.

## 4.1 General DR island system considerations

When designing a DR island system that can provide power to parts of the EPS during an area EPS outage, reliable DR units and careful coordination with the area EPS sectionalizing and protection equipment are necessary. This clause lists issues that are of particular interest when considering implementation of a DR island system. These are further discussed in Clause 5. In order to provide appropriate planning, it is important to understand the general considerations, types of islands, and planned operating conditions.

Important considerations include the following:

— Changes in power-flow magnitude and direction
— Proper control of voltage, frequency, and power quality
— Whether there is a single PCC or multiple PCCs
— Protection schemes and modifications
— Monitoring, information exchange, and control (MIC)
— Load requirements of the area or local EPS that will be islanded
— Characteristics and functionality of the DRs
— Steady-state and transient conditions
— Interactions between electrical energy sources
— Reserve margins, load shedding, and demand response
— Cold-load pickup

The operation of a DR island system also brings up concerns. These include the following:

— A risk of out-of-phase reconnection at all open points not designated and designed for synchronized connection
— Possible damage to equipment due to voltage and frequency aberrations
— Adequate and reliable DR
— Reduced area EPS reliability due to increased system complexity
— Safety for general public, emergency personnel, and operators
— Possible reduction in power quality
— Significant changes in fault duty between normal and island modes
— System protection coordination
— Coordination with load-shedding schemes
— Voltage and frequency regulation


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