Recognized as an
American National Standard (ANSI)

IEEE Std 1547.3™-2007

IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems

Sponsor
IEEE Standards Coordinating Committee 21 on
Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage

Approved 30 October 2007

American National Standards Institute

Approved 17 May 2007

IEEE-SA Standards Board

Abstract: This guide is intended to facilitate the interoperability of distributed resources (DR) and help DR project stakeholders implement monitoring, information exchange, and control (MIC) to support the technical and business operations of DR and transactions among the stakeholders. The focus is on MIC between DR controllers and stakeholder entities with direct communication interactions. This guide incorporates information modeling, use case approaches, and a pro-forma information exchange template and introduces the concept of an information exchange interface. The concepts and approaches are compatible with historical approaches to establishing and satisfying MIC needs. The IEEE 1547™ series of standards is cited in the U.S. Federal Energy Policy Act of 2005, and this guide is one document in the IEEE 1547 series.

This guide is primarily concerned with MIC between the DR unit controller and the outside world. However, the concepts and methods should also prove helpful to manufacturers and implementers of communications systems for loads, energy management systems, SCADA, electric power system and equipment protection, and revenue metering. The guide does not address the economic or technical viability of specific types of DR. It provides use case methodology and examples (e.g., examples of DR unit dispatch, scheduling, maintenance, ancillary services, and reactive supply). Market drivers will determine which DR applications become viable. This document provides guidelines rather than mandatory requirements or prioritized preferences.

Keywords: communications; control; data acquisition; diesel generators; dispersed generation; distributed energy resources; distributed generation; distributed power; distributed resources; distribution system; electric power system; electrical network; energy management; energy storage; fuel cells; grid; IED; information exchange; intelligent electronic devices; interconnection requirements and specifications; meter; microturbines; monitoring; photovoltaic power systems; public utility commission; regulations; rulemaking, federal, national, regional, SCADA; standards; state; substations; supervisory; telemetry; utility grid

---

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Print: ISBN 0-7381-5633-7 SH95697
PDF: ISBN 0-7381-5634-5 SS95697

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. The IEEE develops its standards through a consensus development process, approved by the American National Standards Institute, which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and serve without compensation. While the IEEE administers the process and establishes rules to promote fairness in the consensus development process, the IEEE does not independently evaluate, test, or verify the accuracy of any of the information contained in its standards.

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.
The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied "**AS IS**."

The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

In publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854
USA

Introduction

This introduction is not part of IEEE Std 1547.3, IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems.

IEEE Std 1547.3 is one of a series of standards published by the IEEE or being developed by IEEE Standards Coordinating Committee 21 on Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage concerning distributed resources interconnected with area electric power systems. IEEE Std 1547™ provides interconnection technical specifications and requirements as well as test specifications and requirements; IEEE Std 1547.1™ provides the test procedures for verifying conformance to IEEE Std 1547. The documents in the IEEE 1547 series are as follows:

- IEEE Std 1547™, IEEE Standard for Distributed Resources Interconnected with Electric Power Systems.
- IEEE Std 1547.1™, IEEE Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems.
- IEEE P1547.2™, Draft Application Guide for IEEE Std 1547 Standard for Interconnecting Distributed Resources with Electric Power Systems.[1]
- IEEE Std 1547.3™, IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems.
- IEEE P1547.4™, Draft Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems.
- IEEE P1547.5™, Draft Technical Guidelines for Interconnection of Electric Power Sources Greater Than 10 MVA to the Power Transmission Grid.
- IEEE P1547.6™, Draft Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks.

The IEEE 1547 series of standards is an outgrowth of the changes in the environment for the production and delivery of electricity and builds on prior IEEE standards, recommended practices, and guides developed by the IEEE Standards Coordinating Committee 21 on Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage. In 2005, the United States Federal Energy Policy Act cited and required the IEEE 1547 series of standards for interconnection.

IEEE Std 1547.3 is intended to facilitate interoperability of distributed resources interconnected with an area electric power system. It is intended to help stakeholders in distributed resource installations implement optional approaches for monitoring, information exchange, and control to support the operation of their distributed resources and transactions among the stakeholders associated with the distributed resources. This guide describes functionality, parameters, and methodologies for monitoring, information exchange, and control related to distributed resources interconnected with an area electric power system. The focus is on monitoring, information exchange, and control data exchanges between distributed resource controllers and stakeholder entities with direct communication interactions. This guide incorporates information modeling and use case approaches, but it is also compatible with historical approaches to establishing and satisfying monitoring, information exchange, and control needs for distributed resources interconnected with an area electric power system.

The data exchanges between the distributed resource controller and equipment or entities internal to the local electric power system are not addressed in this guide. The many potential paths of data exchanges among individual stakeholders are also beyond the focus of this document. This guide does not establish requirements for interconnection, protection, safety, or local and area electric power system operation functions. Further, it is beyond the scope of this guide to mandate the business or tariff requirements associated with distributed resources interconnected with an electric power system. However, monitoring,

[1] Numbers preceded by P are IEEE authorized standards projects that were not approved by the IEEE-SA Standards Board at the time this publication went to press. For information about obtaining drafts, contact the IEEE.

information exchange, and control related to such issues and requirements may be ameliorated or satisfied by judicious use of this guide. Finally, specific hardware and software equipment, products, and services are not the subject of this guide.

Notice to users

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: http://standards.ieee.org/reading/ieee/updates/errata/index.html. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: http://standards.ieee.org/reading/ieee/interp/index.html.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims or determining whether any licensing terms or conditions are reasonable or non-discriminatory. Further information may be obtained from the IEEE Standards Association.

Participants

At the time this guide was completed, SCC21 had the following membership:

Richard DeBlasio, *Chair*

Steve Chalmers, *Vice-chair*

Thomas S. Basso, *Secretary*

David Bassett
John J. Bzura
James M. Daley
Douglas C. Dawson
Frank Goodman
Kelvin Hecht
Gerald Johnson
Joseph L. Koepfinger
Benjamin Kroposki
Peter McNutt
Charles W. Rogers
Robert Saint
Mallur N. Satyanarayan
Timothy P. Zgonena

At the time this guide was completed, the Distributed Resources Monitoring, Information Exchange, and Control Working Group had the following membership:

Frank R. Goodman, Jr., *Chair*

Joseph L. Koepfinger, *Vice-chair*

Thomas S. Basso, *Secretary*

Richard Allison
Martin Baier
Arup Barat
David Bassett
Stephen G. Batsell
David Beach
David J.Bosack
Edward A. Brann
Gerard J. Burke
Jim Butler
John J. Bzura
Jim Calore
David Cartes
Frances M. Cleveland
David M. Costyk
Murray W. Davis
Paul A Dolloff
Kevin E. Donahoe
William E. Feero
Joseph F. Galdo
Andris Garsils
Daniel A. Goodrich
Tom Gordon
Erich W. Gunther
Raymond M. Hudson
C. Travis Johnson
Yuri Khersonsky
Brendan Kirby
Stanley Klein
Brenon Knaggs
Ljubomir A. Kojovic
Kevin Komara
John Kueck
Frank Lambert
Jim Lee
James W. Lemke
Jason Lin
Kevin P. Loving
Wayne W. Manges
Sylvain Martel
Paul Mattes
Anthony Mazy
Gary McNaughton
Arun Narang
Gary L. Olson
Barry Peirce
Robert Peterson
Charles Rogers
Steve Rosenstock
Robert Saint
William W. Saylor
Kent Sheldon
Herbert J. Sinnock
Andrew Skok
Sanjeev Srivastava
Wayne Stec
Dennis Tollefson
Amy Vaughn
John Vinod
Tim Wall
Simon Wall
Michael Wang
Randy West
Steve Widergren
Robert Wills
Thomas Yeh
Bob Yinger
Richard Zhang

The following members of the balloting committee voted on this guide. Balloters may have voted for approval, disapproval, or abstention.

William J. Ackerman
Satish K. Aggarwal
Steven C. Alexanderson
Ali Al Awazi
David L. Bassett
Thomas S. Basso
David C. Beach
Wallace B. Binder
Kenneth A. Birt
Stuart H. Bouchey
Steven R. Brockschink
John J. Bzura
James A. Calore
Danila Chernetsov
Frances M. Cleveland
Stephen P. Conrad
Terry L. Conrad
Tommy P. Cooper
Garth P. Corey
F. De La Rosa Costilla
Neal B. Dowling
Michael T. Doyle
Stephen E. Early
Gary Engmann
Manuel Gonzalez
Frank R. Goodman
Randall C. Groves
Ronald D. Hartzel
John F. Hawkins
Dennis Horwitz
R. Jackson
Mark J. Kempker
Yuri Khersonsky
Mark J. Knight
Joseph L. Koepfinger
Jim Kulchisky
Scott R. Lacy
Chung-Yiu Lam
Shawn M. Leard
G. Luri
Keith N. Malmedal
Mark F. McGranaghan
Peter F. McNutt
Joydeep Mitra
Travis Neale
Michael S. Newman
David K. Nichols
T. W. Olsen
Donald M. Parker
Iulian E. Profir
Charles W. Rogers
Bob Saint
Steven Sano
Gary W. Scott
Hyeong J. Sim
Herbert J. Sinnock
Cameron L. Smallwood
Jerry W. Smith
Roger J. Sowada
Sanjeev K. Srivastava
Charles R. Sufana
S. Thamilarasan
James R. Tomaseski
Simon R. Wall
Randall L. West
Charles M. Whitaker
Steven E. Widergren
James W. Wilson
Bernd Wirth
Theodore C. Zeiss
Ahmed F. Zobaa

When the IEEE-SA Standards Board approved this recommended practice on 17 May 2007, it had the following membership:

Steve M. Mills, *Chair*
Robert M. Grow, *Vice Chair*
Don Wright, *Past Chair*
Judith Gorman, *Secretary*

Richard DeBlasio
Alex Gelman
William R. Goldbach
Arnold M. Greenspan
Joanna N. Guenin
Julian Forster*
Kenneth S. Hanus
William B. Hopf
Richard H. Hulett
Hermann Koch
Joseph L. Koepfinger*
John Kulick
David J. Law
Glenn Parsons
Ronald C. Petersen
Tom A. Prevost
Narayanan Ramachandran
Greg Ratta
Robby Robson
Anne-Marie Sahazizian
Virginia C. Sulzberger*
Malcolm V. Thaden
Richard L. Townsend
Howard L. Wolfman

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Satish K. Aggarwal, *NRC Representative*
Alan H. Cookson, *NIST Representativ*e

Michelle D. Turner
IEEE Standards Program Manager, Document Development

William Ash
IEEE Standards Program Manager, Technical Program Development

Contents

IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems

1. Overview

This overview is intended to provide a concise description of the scope, purpose, limitations, and application of this guide. Background information is provided in this clause, and detailed discussions of technical content are provided in the later clauses of this guide. The scope explains what is covered in the guide, the purpose explains why this guide's project is needed, and a subclause on limitations is presented that identifies certain monitoring, information exchange, and control (MIC) aspects not covered in this guide. In other words, the technical boundaries of the guide are discussed in these opening subclauses. Following that, background and introductory information are presented on understanding this guide's general application considerations.

1.1 Scope

This document provides guidelines for monitoring, information exchange, and control of distributed resources (DR) interconnected with electric power systems (EPSs).

1.2 Purpose

This document provides guidelines to facilitate the interoperability of one or more DR interconnected with EPSs. It describes functionality, parameters, and methodologies for MIC of DR interconnected with or associated with EPSs. DR technologies include fuel cells, photovoltaics, wind turbines, microturbines, and other distributed generators as well as distributed energy storage systems.

This guide documents alternatives for sound practice based on current practice and includes both legacy and new MIC systems.

1.3 Limitations

This guide is primarily concerned with MIC between DR units and the outside world. It is not intended for MIC within a device or among the components that make up a DR unit. The data exchanges between the distributed resource controller and equipment or entities internal to the local electric power system are not addressed in this guide. Refer to 1.7 for clarification. The many potential paths of data exchanges among individual stakeholders are also beyond the focus of this document. This guide does not establish requirements for interconnection, protection, safety, or local and area EPS operation functions.

This guide does not attempt to judge the economic or technical viability of specific types of DR, but rather presents guidelines for MIC for specific use cases of DR. Market drivers will determine which DR applications become viable in these use cases. Further, it is beyond the scope of this guide to mandate the business or tariff requirements associated with DR interconnected with an electric power system. However, monitoring, information exchange, and control related to such issues and requirements may be satisfied by judicious use of this guide.

The guide provides a description of the MIC characteristics that support DR installations. The guide is intended to aid DR-interested entities in the identification of MIC issues and solutions to support DR installations. This guide is not wholly comprehensive of the types of applications or the MIC desires of interested parties.

This guide does not address the MIC within the local EPS. (See Figure 1.) It does not address MIC for protection, and it does not address MIC requirements associated with revenue metering.

The guide is not part of any set of information exchange architecture standards for utility systems. Hence, conforming products to this guide does not guarantee they will be compatible with any utility system information exchange architecture.

Finally, specific hardware and software equipment, products, and services are not the subject of this guide.

1.4 Alternative approaches

This document provides guidelines rather than rigid requirements. This means alternative approaches to good practice are suggested but no clear-cut recommendations are made. This document states approaches relative to MIC for DR in EPSs. Example approaches are given, but there is more than one effective way to accomplish the desired results. One approach or another may be easier to implement in a specific user's DR installation, and it is recognized that the user has a choice.

1.5 Different levels of stakeholder needs

Stakeholder MIC needs vary with DR type, size, ownership, and location. In some situations, only minimal DR communications capabilities will be implemented. Additional capabilities may simply not be needed, or the functional benefit may not justify the expense. In other situations, a more comprehensive set of capabilities will be implemented to meet particular stakeholder needs or because the implementation cost is minimal. Although this document lists many potential MIC capabilities, it is important to remember that a wide range of stakeholder needs exists and that a corresponding range of MIC capabilities would be appropriate in these systems. In general, the size of the DR unit and the complexity of the application situation will help the user determine which MIC capabilities from the most relevant use case in this guide should be applied.

1.6 How to use this document

This guide is intended to help stakeholders in DR installations implement alternative approaches for MIC to support the operation of DR and transactions among stakeholders associated with DR. The reader should become familiar with the overall structure and intent of this guide, especially as discussed in Clause 1 and Clause 4.

Clause 1 provides an overview of the guide. Clause 2 presents references that are indispensable for the application of this guide. Clause 3 presents definitions and acronyms. Clause 4 introduces general technical content and application considerations of MIC of DR. Clause 5 contains basic MIC guidelines that focus on 4.16 of IEEE Std 1547™.[1] Clause 6 and Clause 7 present an in-depth treatment of MIC based on forward-looking approaches. In these clauses, guidelines are given for information modeling of DR interconnection applications. Clause 8 identifies example information technology protocol options and guidelines for protocols for MIC. Clause 9 provides guidelines for security issues for MIC in DR applications.

[1] Information on references can be found in Clause 2.

After these clauses, Annex A provides a bibliography. Annex B supports Clause 4 by presenting an annotated list of communications protocols, and Annex C supports this clause by providing additional information about open systems. Annex D is an introduction to business process concepts that supplements Clause 6 and Clause 8. Clause 6 is also supported by Annex E, which provides a use case template, and Annex F, which provides sample use cases. Annex G supplements Clause 7 with sample information exchange agreements (IEAs). Finally, Annex H supports Clause 9 by providing additional information security information.

1.7 IEEE 1547.3 reference diagram for information exchange

Figure 1 provides a reference overview of IEEE 1547.3 guidelines. Its emphasis is conceptual to focus the guidelines on the MIC that are relevant to DR interconnection. The diagram identifies the components that participate in processes of interest. These components are the subjects, or actors, of the process descriptions included in these guidelines. The components in this diagram are consistent with IEEE Std 1547. The new components of the diagram not defined in IEEE Std 1547 are defined in 1.7.1.

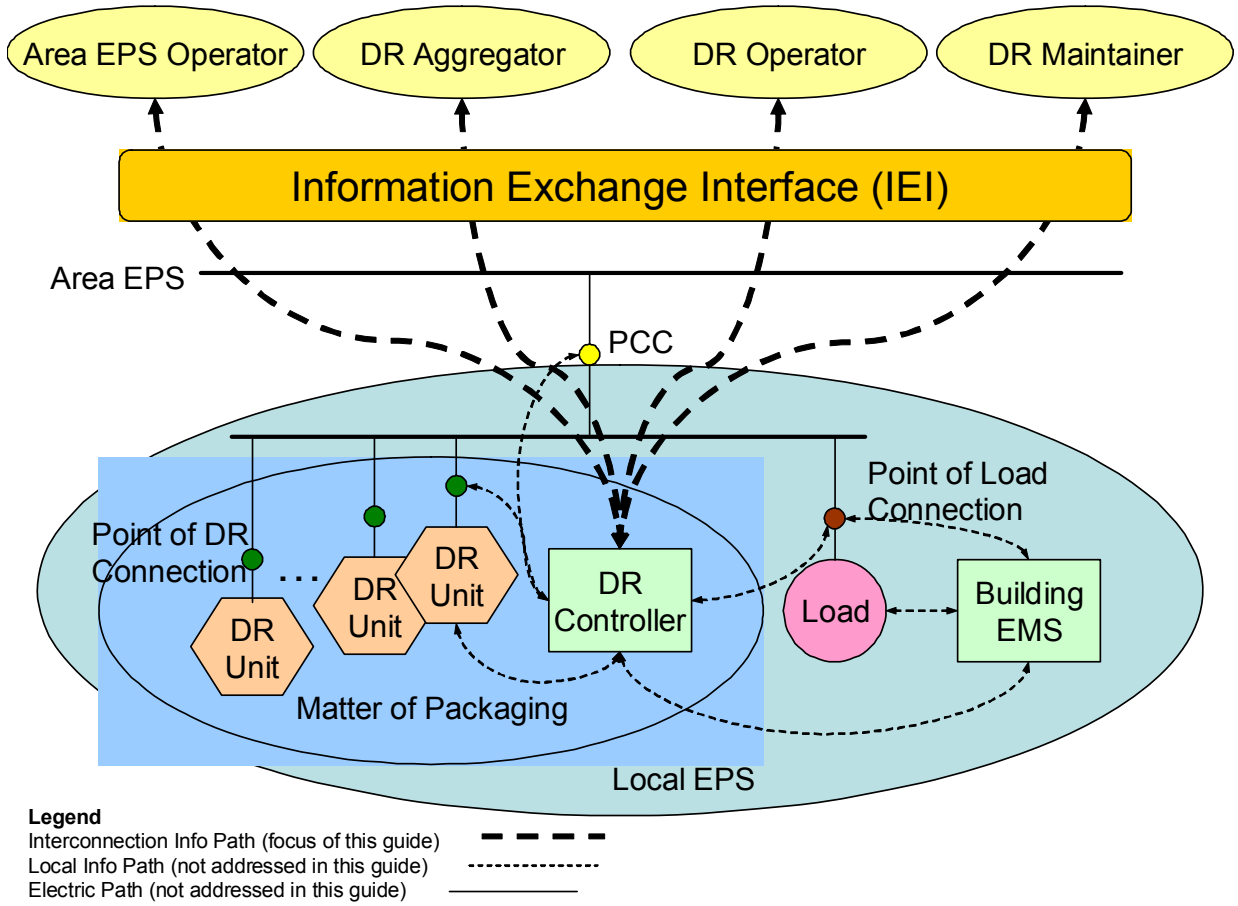

Figure 1— Reference diagram for information exchange

The upper ovals represent the roles of stakeholders who may need to exchange information with the DR system about its interconnection with the area EPS. Other stakeholders are acknowledged as important in the integration of these resources; however, those shown are the subject of the IEEE 1547.3 guidelines (see 1.7.1.2).

The DR units are represented by the hexagons. There may be one or many DR units at a site, but there will be at least one DR controller that performs a monitoring and control function. The DR controller has the intelligence with which to collaborate with stakeholders and site equipment. Note that the DR controller may communicate with these other entities through a communication gateway component; however, for the purposes of the reference diagram, the DR controller subsumes this function. The DR units and controllers can be installed in a variety of configurations. DR units and DR controllers may be packaged together or separately, depending on the business strategy of the manufacturers and the requirements of the clients.

The large circle represents a load. Some loads may be facilities with facility energy management system (EMS) controllers to optimize their operations. A building facility controller is represented as a rectangle and labeled building EMS. Because the focus of the guidelines is on the DR interconnection, coordination of the DR with specific loads on the local EPS may be needed. The building EMS represents the intelligent component for collaboration with the DR controller to enable such interactions as may be needed for combined heat and power applications. The building EMS operator and the DR operator would need to collaborate to ensure appropriate interaction between the DR controller and building EMS for this purpose.

Connections of interest are presented as lines in Figure 1. Solid lines represent electrical connections, and dashed lines represent communication paths. The communication paths are further sub-divided into those that are relevant to the guidelines and those that are acknowledged as important in an installation but are not the focus of this work. Note that communications exist among the stakeholders; however, these are not the subject of these guidelines and, for simplicity, are not shown in the diagram. The heavy dashed lines between stakeholders and the DR controller indicate the focus of these guidelines. The lighter dashed lines are generally required for local monitoring and control of internal device parameters or connection points in the local EPS. They are addressed through various mechanisms (such as standards, de facto standards, and custom implementations) that are generally within the control of the DR site integrator and, therefore, are less relevant to the interconnection with the area EPS and interaction with the DR stakeholders. As noted in 1.3, limitations, local sensing, and control are not the concern of this guide. In addition, the light dashed line between the DR controller and building EMS is included in the diagram to acknowledge that these systems may be integrated at a site to coordinate capabilities such as combined heat and power, but the details of this interaction are not the concern of this guide.

This guide can be thought of in terms of an information exchange interface for the DR device to communicate with remote parties. The information exchange interface could be an actual single point of interface for all remote information flows to and from the device, or it could be an abstraction that represents information flows by multiple, but coordinated, physical media. In either case, this document provides guidance for the information content (e.g., parameters, data, and data rates) that needs to be available at the information exchange interface. The information exchange interface is the information exchange counterpart of the point of common coupling (PCC) in the electrical system.

1.7.1 Diagram terminology

To clarify the terms and concepts in the reference diagram, definitions of the equipment and stakeholder roles follow. The term “role” represents that component of an organization that performs a certain job and interacts with other components in its duties. Organizations can be structured to contain different mixes of roles (e.g., a distribution system company may include area EPS operator (AEPSO), DR operator, and DR maintainer roles). By distinguishing among roles, the information exchange described by these guidelines can be applied to organizations with different combinations of roles. The same holds true for the combinations of equipment components in an installation and the roles they assume.