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IEEE 1547 National Standard for Interconnecting Distributed Generation: How Could It Help My Facility?

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IEEE 1547 National Standard for Interconnecting Distributed Generation: How Could It Help My Facility?

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As energy markets are slowly restructured, customers and utilities are feeling more pressure to control costs and increase operating flexibility. Contributing to this trend is a heightened concern about energy security and the emergence and advanced development of small, modular generation technologies such as fuel cells, photovoltaics, and microturbines. In addition, impressive advances are slated for older, well-established technologies such as reciprocating engines and industrial turbines. The environmental benefits of these distributed power sources exploiting, for example, renewable resources or combined heat and power are substantial.

Projections for new distributed resources (DR) electricity generation capacity range up to 30 GW over the next 20 years, accounting for about 10% of new capacity additions during this period. Attaining the high end of this range depends on improvements in DR unit cost and performance, favorable energy prices, and fewer barriers to DR installations.

IEEE 1547™ 2003 Standard for Interconnecting Distributed Resources With Electric Power Systems was approved by the IEEE Standards Board at its June 2003 meeting and was published in July. This standard is the primary interconnection standard. Ancillary standards for testing, applications, and communications are under development by IEEE work groups. The 1547 standard is the only systems-level technical standard of uniform requirements and specifications universally needed to interconnect DR with the grid.

The approval of this standard should have a significant effect on how the energy industry does business and should influence the electrical distribution system to operate with distributed generators and two-way flow of electric energy. IEEE 1547 is a national standard that has the potential to be used in federal legislation and rule making, state public utility commission deliberations, and the formulation of technical requirements for interconnection agreements by more than 3,000 utilities.

Need for an Interconnection Standard

Distributed generation (DG) not only provides local benefits to its owner, but it also offers new options for utilities. These options range from a physical hedge against purchased power to alternatives to transmission and distribution system upgrades or construction.

Understanding how DG systems are designed, interconnected, and operated is key to understanding the effect of DG on electric power systems and on utilities' goals of maintaining system and supply source reliability. Interconnecting DG to electric power systems can involve system engineering, safety, and reliability considerations. The traditional radial feeders most common on power distribution systems were not designed to accommodate two-way flow of power from active generation and storage at the distribution level, and the technical issues associated with this type of operation are significant. DG

developers have found that the differing interconnection requirements of utilities from state to state, and sometimes within a state, have acted as a barrier to the rapid deployment of DG technologies.

Industry and government have concluded that a standard approach to DG interconnection would lower some of the barriers to DG development. Producers and users of distributed power systems have recognized the importance of having a single document of consensus, standard technical requirements for DG interconnection to avoid having to conform to numerous local practices and guidelines. The single standard was needed to provide uniform criteria and requirements relevant to the performance, operation, testing, safety, and maintenance of the interconnection.

Standards Development by the IEEE

Underlying the advance of DG technologies and markets was a growing sense that a national approach was essential to foster a viable market for distributed power. Government agencies, national laboratories, utility companies, private companies, and equipment manufacturers generally have supported this national approach, which has a strong focus on the development of a national interconnection consensus standard.

The leading organization for electrical standards development is the Institute of Electrical and Electronics Engineers (IEEE), a transnational technical professional society with a membership of more than 350,000 electrical, electronics, and computer engineers in 150 countries. More than 220,000 IEEE members live in the United States. The IEEE Standards Association and its Standards Board have the responsibility of pursuing programs on an IEEE-wide basis that enhance globalization of IEEE standards for promoting the development of electrotechnology and allied sciences and the application of those technologies.

Developing the IEEE 1547 Interconnection Standard

On June 25, 1998, the IEEE Standards Board expanded the responsibilities of IEEE Standards Coordinating Committee 21 (SCC21) to include all distributed generation and energy storage. The first organizational meeting of the expanded SCC21 was held in December 1998 and was hosted by the U.S. Department of Energy in Washington, D.C. In March 1999, the IEEE approved initiation of the standards development project 1547 (P1547):

Title:	IEEE Standard for Interconnecting Distributed Resources With Electric Power Systems
Scope:	This standard establishes criteria and requirements for interconnection of DR with electric power systems (EPSs).
Purpose:	This document provides a uniform standard for interconnection of distributed resources with EPSs. It provides requirements relevant to the performance, operation, testing, safety, and maintenance of the interconnection.

From its inception, the P1547 development activity moved forward on a fast-track basis with unwavering support from industry, utilities, and general interest groups and individuals. The development of 1547 included arduous debate and scrutiny by hundreds of dedicated and experienced individuals. The names of 444 work and ballot group individuals appear in the front of the standard.

The fundamental principles of IEEE 1547 development included:

- A focus on mandatory requirements universally needed for interconnection at the distribution level
- Technology-neutral technical requirements
- Inclusion of DG units with an aggregate size up to 10 MVA at one interconnection point.

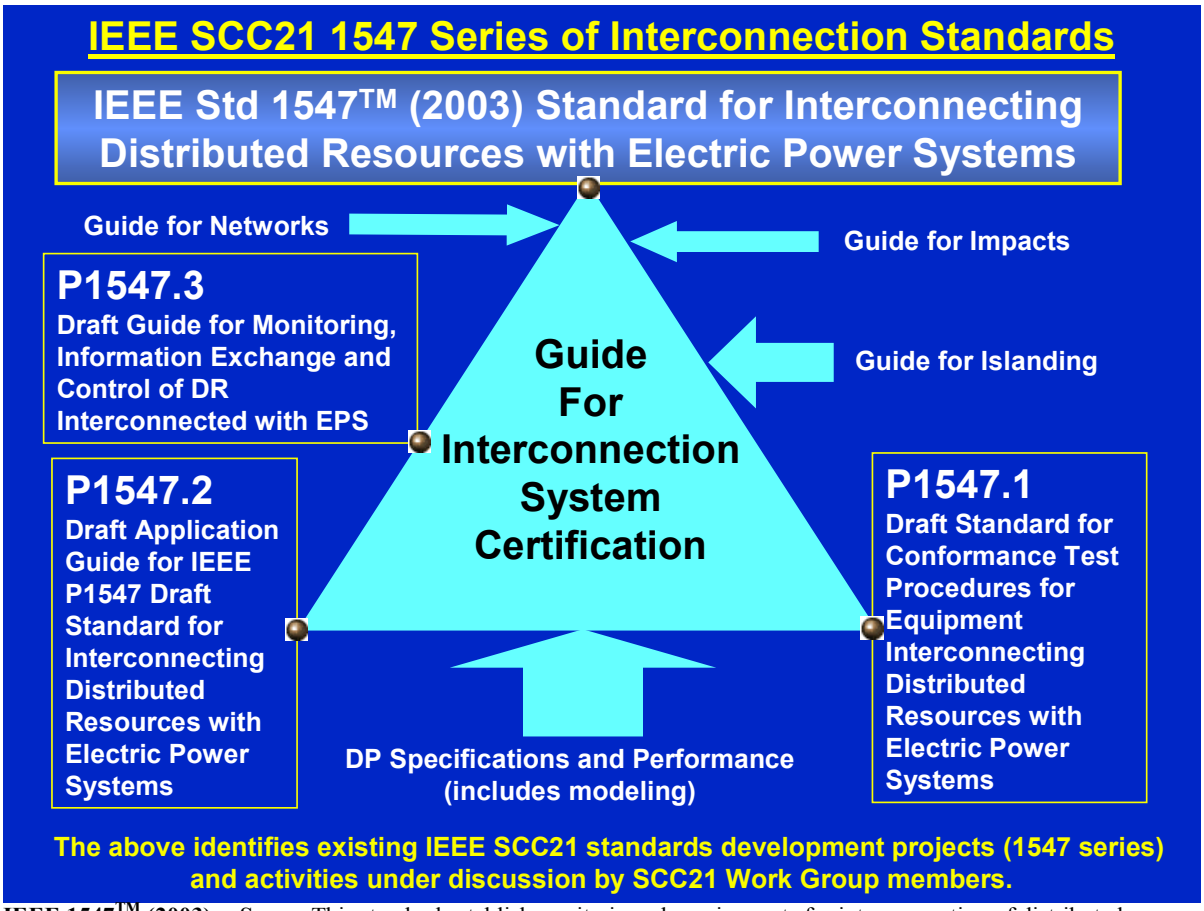
The development of IEEE 1547 was initiated in response to changes in the environment for production and delivery of electricity and builds on prior IEEE-recommended practices and guidelines. As excerpted from IEEE 1547:

> The intent of this standard is to define the technical requirements in a manner that can be universally adopted. The universality relates not only to the technical aspects but also to the adoption of this standard as being pertinent across a number of industries and institutions, e.g., hardware manufacturers, utilities, energy service companies, codes and standards organizations, regulators and legislators, and other interested entities.
>
> This standard focuses on the technical specifications for, and testing of, the interconnection itself, and not on the types of the DR technologies. This standard aims to be technology-neutral, although cognizant that the technical attributes of DR and the types of EPSs do have a bearing on the interconnection requirements. The addition of DR to an EPS will change the system and its response in some manner. Although this standard establishes criteria and requirements for interconnection, this standard is not a design handbook nor is it an application guideline. This standard provides the minimum functional technical requirements that are universally needed to help assure a technically sound interconnection. Any additional local requirements should not be implemented to the detriment of the functional technical requirements of this standard.

Support for this IEEE development activity, both from the members and the electric power community at large, was overwhelming. At the onset, the P1547 work group members unanimously voted to proceed on a fast track, with meetings every other month, to complete a draft for approval in 2001. In March 2001, P1547/Draft 7 was balloted, but it was not approved. The initial ballot highlighted the most challenging issues for consensus. After a rewording of technical requirements, Draft 8 was circulated in the fall of 2001, but once again, it failed approval by the ballot group. It became evident that finely reasoned changes were needed to more clearly capture and state the essence of the mandatory requirements to achieve consensus approval. In October 2001 and January 2002, working group participants conducted more focused reviews resulting in P1547/Draft 9. In June 2002, a meeting of working and ballot group members arrived at a modification resulting in endorsement of a new ballot on P1547/Draft 10. That ballot succeeded with 90% affirmation. But IEEE protocol required an attempt to resolve individual negative ballots and recirculation of any subsequent unresolved negative ballot comments to the full ballot group. Finally, in February 2003, P1547/Draft 11—with minor rewording—received 91% affirmation from the ballot group of 230 members.

IEEE 1547 Series of Interconnection Standards

During the working group meeting of January 2001, the development of complementary interconnection standards was discussed. Subsequently, the three standards identified in Figure 1 as P1547.1, P1547.2, and P1547.3 were formally initiated after their approval by the IEEE Standards Board for draft development. These ongoing projects were deemed the first priority after 1547 development. The additional activities in the figure are also high priorities and will be considered as volunteers' time and resources become available. These additional 1547 series projects will further efforts to create the standards foundation for DG and support its widespread deployment over the next decade.



IEEE 1547™ (2003) -- Scope. This standard establishes criteria and requirements for interconnection of distributed resources (DR) with electric power systems (EPSs). **Purpose**. This document provides a uniform standard for interconnection of DR with EPSs. It provides requirements relevant to the performance, operation, testing, safety, and maintenance of the interconnection.

P1547.1 -- Scope. This standard specifies the type, production, and commissioning tests that shall be performed to demonstrate that interconnection functions and equipment of a DR conform to IEEE 1547. **Purpose**. Interconnection equipment that connects DR to an EPS must meet the requirements specified in IEEE 1547. Standardized test procedures are necessary to establish and verify compliance with those requirements. These test procedures must provide both repeatable results, independent of test location, and flexibility to accommodate a variety of DR technologies.

P1547.2 -- Scope. This guide provides technical background and application details to support the understanding of IEEE 1547 Standard for Interconnecting Distributed Resources With Electric Power Systems. **Purpose**. This document facilitates the use of IEEE 1547 by characterizing the various forms of DR technologies and the associated interconnection issues. Additionally, the background and rationale of the technical requirements are discussed in terms of the operation of the DR interconnection with the EPS. Presented in the document are technical descriptions and schematics, applications guidance, and interconnection examples to enhance the use of IEEE 1547.

P1547.3 -- Scope. This document provides guidelines for monitoring, information exchange, and control for DR interconnected with EPSs. **Purpose**. This document facilitates the interoperability of one or more DR interconnected with EPSs. It describes functionality, parameters, and methodologies for monitoring, information exchange, and control for the interconnected DR with, or associated with, EPSs. DR include systems in the areas of fuel cells, photovoltaics, wind turbines, microturbines, other distributed generators, and distributed energy storage systems.

Figure 1. IEEE Interconnection Standards (See http://grouper.ieee.org/groups/scc21/dr_shared/)

Applying IEEE Std 1547

Power engineers and other stakeholders looking to the future now have the opportunity to draw upon the published IEEE 1547 and the increasing DG experiences and resources coming to light. But even after publication of IEEE 1547, additional barriers remain to the orderly transition to the integration of all distributed power sources with EPSs. For example, a lack of straightforward responsiveness is sometimes the case for decisions regarding national building and safety codes and permitting as well as for state public utility commission and local utility judgments. And it is often touted that present power distribution system technology and operation do not inherently allow the full realization of the benefits of distributed power. However, the concerns underlying these issues are often less attributable to technical foundations than to misunderstandings and lack of experience.

The IEEE P1547.2 draft application guide to IEEE 1547, when complete, will provide utilities and DG owners/developers with an approved, hands-on document that outlines alternative methods of addressing the requirements of IEEE 1547. Although IEEE 1547 provides the technical requirements for interconnection on a functional basis, P1547.2 will describe rationale and background for further understanding (e.g., protective relaying and coordination hardware arrangements, grounding configurations, etc.) to help address the functional requirements of IEEE 1547.

How Will IEEE 1547 Help My Facility?

The new IEEE 1547 interconnection standard is expected to help reduce the costs and other barriers to grid interconnection by offering a cost-reduction and reliability-enhancing opportunity to DG owners and operators. Third-party developers and power generation equipment operators are also available to assist in implementing DR interconnection and assume the technical and performance risk of this equipment.

When properly integrated with the grid, DG has potential benefits such as reduced electric line loss; grid/EPS investment deferment and improved grid/EPS asset utilization; improved reliability; ancillary services such as voltage support or stability, VARs, contingency reserves, and black start capability; clean energy; lower-cost electricity; reduced price volatility; greater reliability and power quality; energy and load management; and combined heat and power (CHP) synergies. These benefits tend toward the evolution of a modernized EPS with greater flexibility and energy security for the future.

Further, DG, especially in CHP mode, has the potential to dramatically reduce industrial and commercial sectors' carbon and air pollutant emissions and increase source energy efficiency. In CHP mode, overall energy effectiveness is enhanced because CHP produces electricity and usable byproduct thermal energy onsite, converting 80% or more of the fuel into useable energy. Some of the DG technologies, such as gas-fired reciprocating engines and microturbines, readily lend themselves to CHP applications and can deliver both electricity and heating or cooling to buildings and other commercial facilities or processes. And renewable energy resources may provide additional value in conjunction with more traditional prime movers for consideration in DG projects.

In closing, the publication and implementation of IEEE 1547, in conjunction with the impressive advances in DG technologies, should have a significant effect on how the energy industry does business. The standard should constructively influence the way EPSs operate with distributed generators. It should provide a technical basis for enabling increased deployment of DG. And now, the utilities, their customers, and DG and third-party developers have IEEE 1547 as another tool to help realize the grid of the future today by having various forms of DG effectively contribute to our energy needs.

Thomas (Tom) Basso is an engineer-scientist working at the National Renewable Energy Laboratory (NREL) under the Distributed Energy and Electric Reliability Program's Distribution and Interconnection R&D area; serves as secretary for IEEE SCC21, P1547.2, and P1547.3 standards development; and manages the US Technical Advisory Group for the International Electrotechnical Commission Technical Committee 8 Systems Aspects of Electrical Energy Supply.

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13. ABSTRACT *(Maximum 200 words)*
This article summarizes the purpose, development, and impact of the Institute of Electrical and Electronics Engineers 1547 Standard for Interconnecting Distributed Resources With Electric Power Systems. Also included is a short explanation of supporting standards IEEE P1547.1, P1547.2, and P1547.3.

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