Business & Technology Strategies

TechSurveillance

Revision of IEEE Standard 1547™
The Background for Change

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This article is the first in a four-part series regarding the IEEE standard 1547 and its impact on the electric grid. The background and purpose of this standard is discussed here, and subsequent articles will focus on related issues of voltage regulation, disturbance performance, and power quality. A primary purpose of this series is to ensure cooperatives are well informed of the importance of this standard and the upcoming related balloting session, and of the opportunity to be involved in the process to ensure their perspective is reflected in upcoming changes to the standard.

ARTICLE SNAPSHOT

What is the issue in the industry?
IEEE Standard 1547, which defines interconnection requirements for distributed energy resources (DER), is presently undergoing a major revision. The present version of this standard was adopted in 2003, prior to the present surge of DER penetration into the grid and major changes in DER technology and economics.

What is the impact on cooperatives?
Cooperatives, as well as all other electric utilities, are experiencing significant growth in DER interconnection applications. Unlike the situation in 2003, when DER was considered to have a relatively minor impact or at most an isolated impact, DER at the penetration levels experienced in many areas can have substantial impact on utilities, the reliability of the grid, and the quality of electric service to other utility customers. The revisions of IEEE 1547 are intended to mitigate many of these DER impacts. The new standard will determine how DER devices are designed and tested, and will define how DER will be integrated into the power system going forward.

What do cooperatives need to know or what can they do about it?
The revised standard can only meet its goals if it adequately considers the wide range of utility distribution system characteristics and design practices. Rural electric cooperatives have unique situations, constraints, and practices that are less frequently encountered by investor-owned utilities (IOUs). As the standard's draft development is now reaching conclusion, co-op engineers are encouraged to join the ballot pool to ensure that the standard adequately addresses the needs of the cooperative community.

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Cooperatives are encouraged to become involved in the review and balloting of the IEEE 1547 proposed revision to ensure it sufficiently addresses co-op system circumstances.

IEEE 1547 is strictly focused on distribution-system-connected resources.

INTRODUCTION

Much has changed in America since the dawn of the new millennium. Likewise, the status and role of distributed energy resources (DER) today has changed greatly from the 1999–2003 time period when the present IEEE Standard 1547™-2003 for DER interconnection was developed. DER, which includes distributed generation, most notably solar, has become much more pervasive and other DER technologies, such as energy storage, have evolved substantially. Therefore, there has been an ever-increasing need to revise this standard to meet today's needs.

A major revision of IEEE 1547 has been underway since 2014, with the standard draft being developed by the IEEE working group approaching the balloting stage. This *TechSurveillance* article is the first in a series of four that will describe the changes that are proposed for this standard, provide the rationale for these changes, and describe how they will affect the planning, design, and operation of rural electric cooperative distribution systems into the future. Although it is now in the final drafting stage of the development process, cooperative engineers are encouraged to become involved in the review and balloting of this proposed standard revision to ensure that it sufficiently addresses their system circumstances.

ORIGINS OF IEEE STANDARD 1547 — THE NATIONAL DER INTERCONNECTION STANDARD

IEEE 1547 has become the primary standard for DER interconnection in North America, and has been adopted by numerous regulatory agencies and utilities. It effectively defines how DER equipment for the North American market is designed and tested, and how DER projects are connected to utility systems. The standard establishes uniform requirements for the system-affecting characteristics of individual DER installations, including:

- Impact on the voltage of other customers
- System grounding integration
- Response to abnormal system events, such as faults and frequency deviations
- Tripping requirements when the DER becomes islanded
- Power quality impacts, including harmonics and flicker

The standard prescribes the basic testing requirements for DER equipment at the design type-test stage, as well as production testing. The standard also provides requirements and guidance for interconnection evaluation and commissioning of DER facility projects.

The standard is focused on the individual DER installation, whether it is one DER unit or many units within a customer's system, and not on the cumulative system impact of multiple DER facilities. Requirements are applicable at the point of common coupling (PCC) of the DER installation with the utility system (with some inconsistency, as some requirements appear to be focused on the DER unit terminals even if buried within a customer's facility). Therefore, the standard does not address DER penetration limits or broader system planning issues.

The scope of IEEE 1547 is strictly focused on distribution-system-connected resources, and does not address generation facilities that are connected at the transmission or sub-transmission system levels, even if they are composed of many small generation units, such as transmission-connected wind farms. The 2003 version of the standard also limited its applicability to DER facilities having an aggregate capacity of 10 MVA or less.

The primary driver for the standard was the perception that utilities were creating barriers to interconnecting DER.

For most utilities, the connection of generation onto radial distribution systems was unknown and there were concerns that distribution systems were not designed to accommodate generation and storage.

Historical Background of IEEE 1547

IEEE 1547 was developed and continues to be developed by the IEEE Standards Association's Standard Coordinating Committee (SCC-21), which is independent of the IEEE's technical societies, such as the Power and Energy Society (PES) or Industry Applications Society (IAS). SCC-21's scope is fuel cells, photovoltaics, dispersed generation, and energy storage. A large industry working group, with over 350 members, developed the original 2003 standard over the period from 1999 to 2002. Balloting of the standard was completed and the standard was officially adopted by IEEE in 2003.

The original standard development was an often contentious process. When the process began, some observers believed that utilities generally had an aversion to interconnecting generation resources to distribution systems, and DER proponents had a general lack of understanding and appreciation of the design and operational issues of a utility system. The primary driver for standardizing DER interconnection technical requirements was the perception that utilities were creating barriers to interconnecting DER by creating unduly restrictive and inconsistent technical requirements. With heavy influence from the DER manufacturers, the US Department of Energy (DoE) initiated a project to fund the development of the IEEE 1547 standard. Working through the National Renewable Energy Laboratory (NREL), whose employees and consultants filled the key leadership positions in the standard development working group, DoE funded the supporting work and meeting logistics. The DoE support was instrumental in accelerating the development of the Standard and facilitated the maximum attendance in working group meetings.

From the perspective of most utilities, the connection of generation onto radial distribution systems was unknown and they took a conservative approach to ensure that the impacts on the reliability of the distribution systems were as low as possible. In June 2000, the Edison Electric Institute (EEI) published a "Distributed Resources Task Force Interconnection Study" outlining "29 Issues" for interconnection of DG to distribution systems. In some ways, this document was used to advance the notion by manufacturers that utilities were raising barriers to DG interconnection. These concerns by both utilities and manufacturers are addressed in the introduction to IEEE 1547, which recognizes that utility distribution systems were not designed to accommodate generation and storage, and technologies to minimize impact were still in the process of evolving.

The first several meetings of the original working group were largely devoted to dialog between utilities and manufacturers to understand each other's issues and concerns. The utilities wanted to maintain safe and reliable systems, and the manufacturers wanted consistent and reasonable technical standards, so that they could deploy their projects with predictable requirements and costs. This timeframe was when utility deregulation was in vogue, and some regulatory participants were adamant that the standard should leave no discretion to the utilities regarding interconnection requirements. Each side got some of what it desired, but not all. The final standard was largely a compromise that is somewhat vague and thin on detail, and left several issues open for variant interpretations.

NRECA AND CO-OPS HELPED SHAPE THE ORIGINAL STANDARD

There was participation by NRECA and the cooperative community in the original standard development process. Paul Dolloff, with East Kentucky Power, was a working group member representing NRECA's T&DEC System Planning Subcommittee. Because of the huge size of the working group, a smaller "writing group" was formed to handle the details of the standard's wordsmithing, and Paul was a member of this inner group as well. Bob Saint, Principal Engineer at NRECA at the time, joined later in the development process. Jay Morrison of the NRECA regulatory staff became involved in the final negotiations of the working group, and was instrumental in getting the key footnote "Additional technical requirements and/or tests may be necessary for some limited situations." inserted in the document.

The context in which IEEE 1547 was developed differs greatly from the DER situation today… PV was not seen at the time as having the potential to be a big factor.

The IEEE 1547.x Family of Standards

IEEE 1547 was the master or lead standard in a series of IEEE standards, recommended practices, and guides related to DER interconnection. These documents form the 1547.x family of standards. The sidebar below lists the companion standards in this series.

In addition to the adopted standards listed, there is another document in the series that is technically in process. This is P1547.8 ("P" indicates a standard undergoing development), which has the rather wordy title "Recommended Practice for Establishing Methods and Procedures that Provide Supplemental Support for Implementation Strategies for Expanded Use of IEEE Standard 1547." This recommended practice is intended to address the issues attendant to high DER penetration. Some see this as an attempt to mollify concerns that IEEE 1547-2003 has not kept up with the changing DER environment, without making changes to the base IEEE 1547 standard. This standard had nearly reached the balloting stage, but further activity has apparently been suspended due to current attention on the revision of the base IEEE 1547. (Revision of the base standard is now underway due to *force majeure*, as explained later.) A standard with suffix ".5" does not appear in this sidebar. This number was reserved for a standard defining transmission interconnections, but actual development of this standard never took place and the IEEE-SA (IEEE Standards Association) project authorization has expired.

COMPANION STANDARDS IN THE 1547 SERIES

- **IEEE 1547.1-2005 – IEEE Standard Conformance Test Procedures for Equipment Interconnecting Distributed Resources with Electric Power Systems** — Provides detailed DER interconnection equipment testing procedures for conformance to IEEE 1547 requirements.
- **IEEE 1547.2-2009 – IEEE Application Guide for IEEE Std 1547™, IEEE Standard for Interconnecting Distributed Resources with Electric Power Systems** — Provides technical background and applications details to support understanding and utilization of IEEE 1547-2003.
- **IEEE 1547.3-2007 – IEEE Guide for Monitoring, Information Exchange, and Control of Distributed Resources Interconnected with Electric Power Systems** — Provides guidelines to facilitate the interoperability of DER with utility SCADA systems.
- **IEEE 1547.4 – IEEE Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems** — Provides guidelines for the design and operation of intentional islands, sometimes called microgrids.
- **IEEE 1547.6-2011 – IEEE Recommended Practice for Interconnecting Distributed Resources with Electric Power Systems Distribution Secondary Networks** — Provides recommendations for interconnecting DER to the secondary grid networks found in some urban areas.
- **IEEE 1547.7 – IEEE Guide for Conducting Distribution Impact Studies for Distributed Resource Interconnection** — Provides scope and guidelines for the performance of DER interconnection studies.

Adoption and Application of IEEE 1547

IEEE standards are, by definition, voluntary standards. However, many states have adopted IEEE 1547 and effectively made it a law, whether through statute or regulation. In general, over most of the US, IEEE 1547 is the law of the land and constrains the requirements that utilities and state regulatory commissions can place on interconnecting DER. As the DER situation has changed dramatically since 2003, the dated requirements of the standard have presented some difficulties.

THE CHANGING DER ENVIRONMENT

The context in which IEEE 1547 was developed differs greatly from the DER situation today. At that time, high DER penetration was not on the horizon in the vision of most involved. Continuous DER operation was considered unimportant to the grid; to the contrary, it was generally viewed as an impediment if there is a disturbance on the distribution system. In the case of storm damage or vehicle accidents, sensitive tripping was seen as providing additional assurance of avoiding potentially significant hazards. Therefore, IEEE 1547 requires DER to disconnect immediately for even moderate system disturbances, and to stay off until the system has been stable for a period of several minutes. While still a major concern of utilities today, the overriding objective of the sensitive tripping requirement was the avoidance of DER-fed islands. *(Islands* are where operation of a breaker, recloser, or fuse disconnects DER along with a portion of the feeder's load and the DER remains in service to energize the island.) Fast and sensitive tripping was also intended to limit the duration of DER fault current contribution, which can increase equipment damage and interfere with protective device coordination.

Co-ops' focus on meeting member needs increasingly means interconnection of member-owned DER.

In the era when this standard was under development, the type of DER in most working group members' minds was conventional engine-driven synchronous generators. These generators do have significant fault current contribution and can more easily sustain an inadvertent island. The new technologies gaining attention then were microturbines and fuel cells, with the latter to exploit the "hydrogen economy" that was the futuristic fad du jour. Photovoltaic (PV) DER existed, but was not a major portion of DER, and the common view then was that PV was too expensive and would never be a big factor.

Much has changed since 2003 with the increased penetration levels of DER as well as the mix of DER technology.

DER Penetration Growth

Needless to say, much has changed since 2003. DER penetration levels have reached high levels in many areas, particularly where energy prices are high or where public policy has provided incentives. Some feeders in several states have DER capacity in excess of load demand. The high energy price driver for DER has been a large factor in Hawaii, California, and in the Northeast. Many of these states also have strong incentives for DER, such as tax credits and net electrical metering (NEM) policies. While it is generally true that high DER penetrations have appeared primarily in states which already have favorable DER policies, penetration is also on the increase in other states, due to decreasing DER prices, federal tax credits, and increasing policy-based incentives by other states. As member-owned entities, cooperatives strive to meet the desires of their members, and increasingly that means interconnection of member-owned DER.

One co-op having a very high penetration of DER is Kauai Island Utility Cooperative (KIUC) in Hawaii. Historically, most of the electric power generated on Kauai was based on expensive imported petroleum, resulting in particularly high electric energy prices. This has been a strong motivator for KIUC and their members to install all types of DERs including biomass, hydo, and PV units on homes and businesses. In January, 2016, KIUC had several periods where solar PV (rooftop and utility-scale projects) contributed up to 77 percent of the co-op's entire load demand at those times. A few KIUC distribution feeders have PV penetration, based on PV nameplate AC capacity, approaching 90 percent of feeder load. For more information, please see NRECA's related *TechSurveillance* article: ***Kauai Island Utility Cooperative: The Impact of Extensive PV Penetration***.

The mix of DER technology has also changed dramatically since 2003. Microturbines have evolved to a niche solution, favored where combined heat and power (CHP) is desired due to the relatively high exhaust temperature of these units. The "hydrogen economy" hype has come and gone, and fuel cells have become an even smaller niche. Engine-driven generators have maintained a stable market, particularly where the primary application is standby power (but sometimes used to provide grid peaking) or for exploitation of biogas resources. The latter probably is a more significant application in rural areas, relative to the urban and suburban service areas dominating most investor-owned utilities. The big shift, however, is the rapid growth of PV DER. PV is very modular and readily implemented in small NEM applications.

Prices of DER equipment have decreased dramatically. For example, solar PV installed prices have plummeted to 40 percent of the prices existing when the standard was developed, as shown in Figure 1. As a result of both policy and price, PV is now by far the largest share of DER installations. PV comes in both small rooftop behind-the-meter applications, as well as MW-sized utility-scale solar farms developed as wholesale electric power generators.

As a result of both policy and price, PV is now by far the largest share of DER installations.

PV leads to different impacts on power systems than the DER types in mind when IEEE 1547-2003 was developed. PV is a highly variable resource, with output of individual installations capable of ramping up or down nearly the full power rating in a matter of seconds as cloud shadows pass over. PV DER is interconnected to the grid using power-electronic inverters. These inverters have very different characteristics than the synchronous machines previously dominant. Their fault current output is very limited, and thus, they have much less potential for interference with utility protection coordination. They are current-regulated devices, unlike synchronous generators which are voltage sources, and their impact to system grounding is much different.

When DER, particularly variable generation like PV, becomes a large factor on a distribution feeder, there can be significant voltage impacts. Voltages may be driven high, voltage regulation can become uncoordinated, and voltage variations may cause unusual wear and tear duty on feeder voltage regulators and substation transformer tap changers. It is possible for the DER, through the use of reactive power, to mitigate these issues to a great degree in many situations. However, the IEEE 1547-2003 explicitly forbids DER from performing "active voltage regulation." This was intended to prohibit a reactive power output that is changed in response to measured voltage, but has been frequently misinterpreted as a requirement that DER units only operate with unity power factor.

When DER, particularly variable generation like PV, becomes a large factor on a distribution feeder, there can be significant voltage impacts.

This voltage regulation prohibition had its roots in the controversies of the era when the standard was developed. Through much of the standard development process, participation by DER in voltage regulation was to be permitted, if agreeable to the utility. There was a vocal faction of the working group opposed to allowing utilities any discretion in the terms of DER interconnection whatsoever, including discretion regarding the application of DER voltage regulation functionality. Because voltage regulating equipment connected to a distribution feeder without coordination with the utility would cause chaos, the final drafts of the standard incorporated this voltage regulation prohibition. This has tied the hands of some utilities and developers, even when both agree that this functionality is the better solution for all concerned. Today, both the developers and utilities have greater mutual understanding, and it has become recognized that utilities need to have some technical discretion regarding DER interconnection requirements.

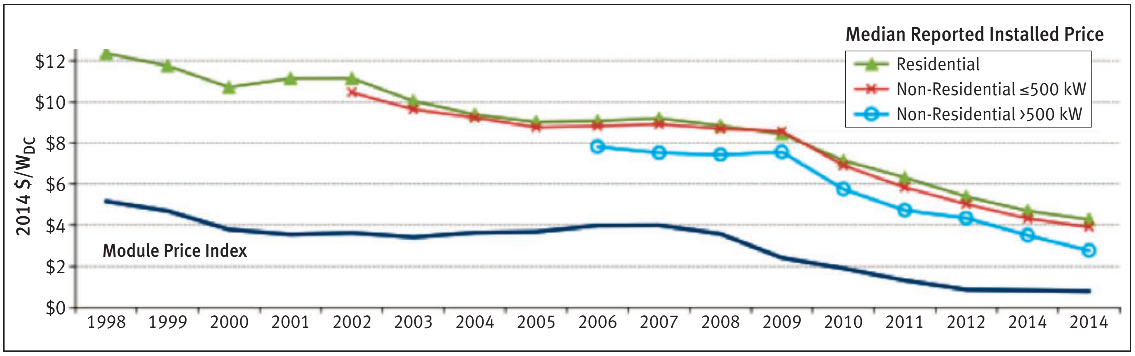

FIGURE 1: Median installed PV price trends. *Source: US Department of Energy.*

A transmission fault can cause DER over a wide area to trip simultaneously.

The very worst thing that can happen when frequency dips is for more generation to trip in response.

The impact on frequency deviations depends on the total generation-load over the entire interconnection… DER does not have to be in an area of local or regional high penetration to have an impact.

Impact on Bulk Grid Stability

DER tripping thresholds built into IEEE 1547-2003 are based on very tight voltage and frequency parameters. As noted earlier, these settings provide the maximum degree of safety for the distribution system in the event of vehicle accidents, downed lines or other contacts.

The "just get off" approach to DER tripping for disturbances, however, is increasingly discussed as a potential threat to the security and reliability of the bulk power system. For the bulk power system, a transmission-level fault can cause substation bus voltages to be depressed over a wide geographic area. Because distribution systems are radial, and most inverter-based DERs do not provide sufficient short-circuit current to "prop up" the voltage at their location when motor loads are stalling, the voltages sensed by DER are likely to be even less than the substation voltages. As a result, a transmission fault can cause DER over a wide area to trip simultaneously. In regions of the U.S. with extensive DER penetration (e.g., California, Massachusetts), a transmission fault could result in substantial amounts of DER generation output disappearing instantly. Transmission systems are not designed for loss of generation to occur in conjunction with a line fault, except for the loss of capacity associated with a fault on a specific generator's radial tie line. This substantial loss of generation can potentially cause the initial disturbance to cascade and result in grid instability. While such high DER penetration levels are not likely to occur on cooperative systems in the near future, except for special circumstances such as Kauai, IEEE 1547 addresses DER interconnections nationwide.

Similarly, DER tripping during a grid frequency deviation can also have adverse consequences. A grid under-frequency event is usually caused by a significant loss of generation. The very worst thing that can happen when frequency dips is for more generation to trip in response. Bulk generators have a very strict standard (NERC PRC-024) that does not allow tripping for under-frequency events less severe than a defined frequency-time profile. The under-frequency tripping points specified in IEEE 1547 are more sensitive than the profile specified for bulk generators. Also, the IEEE 1547 specification is for the maximum frequency deviation and duration; a DER can be tripped well before these thresholds are reached. Thus, DER tripping may compound a grid under-frequency event.

During an over-frequency event, tripping of generation may reduce the over-frequency. However, too much generation tripping at precisely the same threshold can cause an over-frequency situation to instantly become a severe under-frequency event. Germany is farther down the road of DER penetration than the U.S., and it was realized too late that simultaneous tripping of all DER at 50.2 Hz (compared to the 50 Hz nominal frequency used in Europe), as required by their previous interconnection standard, could potentially plunge the country into a blackout. As a result, over 200,000 field-installed DER had to be retrofitted to avoid this issue. Right now, IEEE 1547 requires tripping of DER at 60.5 Hz in less than ten cycles, presenting a similar risk here.

It is important to note that the frequency is the same across an entire interconnection. The continental U.S., exclusive of Alaska, has three power system interconnections: WECC, the Eastern Interconnection, and ERCOT as illustrated in **Figure 2**. The impact of DER on frequency deviations depends on the total generation-load balance over the entire interconnection. Therefore, the impact on the total generation of any DER unit tripping as a result of an interconnection's frequency deviation does not depend on where the DER is located within the interconnection. DER does not have to be in an area of local or regional high penetration to have an impact. In other words, a 10 kW rooftop PV located in the Los Angeles basin along with

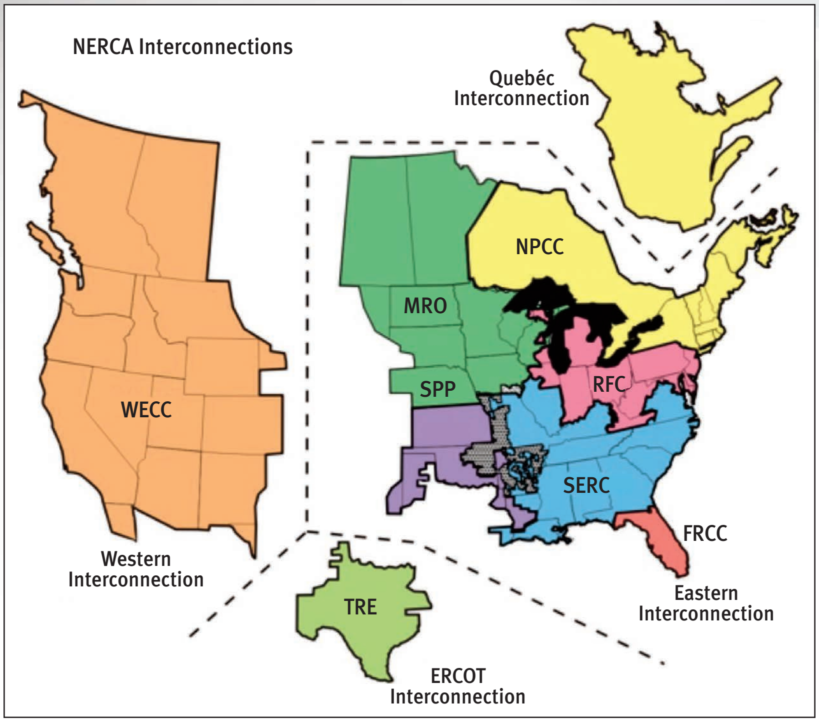

FIGURE 2: Power grid interconnections in North America. *Source: http://sites.utexas.edu/mecc/files/2013/10/NERC_Interconnections_color.jpg*

thousands of other similar units has exactly the same individual contribution to WECC frequency stability as does the same size unit on a lonely feeder in Wyoming where there might not be another DER in the entire county.

The proliferation of DER compliant with IEEE 1547-2003 increases the risk of bulk power system instability.

The proliferation of DER compliant with IEEE 1547-2003 increases the risk of bulk power system instability. A study by GE, reported at several conferences soon after the standard was adopted, showed simulations of a severe transmission contingency in the WECC, with and without sensitive DER tripping. The DER penetration for the study was assumed to be 20 percent of load, which is beyond current levels but could be achieved a few years out in the future. The simulations showed system-wide instability (i.e., blackout across the entire western U.S.) with sensitive DER tripping, and stable performance if the DER were allowed to ride through the event.

The likely impacts of DER on system stability were recognized by NERC in their Integration of Variable Generation Task Force 1-7 Report, released in 2013. In this report, NERC calls for DER to have capability to ride through a much wider range of grid disturbance severity, as a necessary measure to preserve the security and reliability of the nation's power grid. Distribution systems, and the DER that connect to these systems, are outside of NERC's jurisdiction, however. Solving this problem is further complicated by the mandate of IEEE 1547 for sensitive trip levels which has the effective force of law in many states. NERC has stated their preference to stay out of regulating distribution systems. They hope that the final revisions to IEEE 1547 will be sufficient to cover their concerns for the impact of DERs on the bulk electric system.

AMENDMENT OF IEEE 1547

Prior to 2014, IEEE standards had a life of five years. The sponsoring committee (SCC-21 in the case of IEEE 1547) had the option of placing the expiring standard up for reaffirmation ballot, or it could convene a working group to revise the standard and present a new draft for balloting as a replacement to the existing. Many other committees sponsoring IEEE standards maintain a standing working group to review and update their standards as necessary. This even includes standards in such staid areas as surge arresters. Despite the rapid changes in DER penetration and technology, the IEEE 1547 working group was disbanded after the standard was adopted, and no standing working group for review and updating was convened. Instead, SCC-21 put the 2003 version up for reaffirmation ballot in 2008. Faced with the choice between either reaffirming the old version or having the standard expire without a replacement until a working group could forge a replacement, the industry went with reaffirmation.

There is a need for the national interconnection requirements, as defined by IEEE 1547, to be updated to meet the needs of today and the immediate future.

The draft for an updated IEEE 1547 standard is in final stages and expected to be put up for ballot the first half of 2017.

As DER penetration increased, so did the calls for change. The P1547.8 project was initiated, viewed by some as a workaround to avoid updating the standard. The pressure to make changes, particularly with regard to voltage and frequency disturbance ride-through and participation of DER in voltage regulation, resulted in a working group convened in 2012 to amend the IEEE 1547 standard. This amendment, IEEE 1547a, was published in 2014 and allowed wider trip points for voltage and frequency deviations under mutual agreement of the DER owner/operator and the utility, but did not mandate that DER have ride-through capability. Likewise, voltage regulation participation was permitted, but DER was not required to have this functionality.

NERC's position was that this was insufficient for support of the BES and that all DERs must have mandatory ride-through capabilities. They view this as critical to the reliability of the bulk electric system, especially as DERs continue to displace conventional generation. At the first meeting of the Working Group in April 2014, they restated this position and expressed their hope that the WG could find a solution which would enable DERs to support the BES while maintaining safety for local conditions.

California and Hawaii, where DER penetration is particularly large, have decided that IEEE 1547-2003 is inadequate to meet the needs of utility customers in their states. These states have developed and implemented requirements for advanced grid-supporting capabilities in PV inverters interconnected to distribution systems within their states. The prospect of each state setting their own requirements on DER equipment manufacturers, however, is a prescription for chaos. Clearly, there is a need for the national interconnection requirements, as defined by IEEE 1547, to be updated to meet the needs of today and the immediate future.

FINALLY, A NEW IEEE 1547

In 2014, the IEEE-SA changed its standards policy. The lifespan of IEEE standards were extended to ten years, but the option to reaffirm existing standards, without change, was removed. Instead, a working group now needs to be convened, preferably prior to the expiration of a standard, to reconsider all aspects of the standard. This is the force majeure that began the process of developing a new IEEE 1547. The old standard, last reaffirmed in 2008, will expire in 2018. In 2014, a new P1547 working group was convened and is now well along the path to completing a completely revised IEEE 1547. The standard draft is now in the final stages of pre-ballot fine tuning, and is expected to be put up for ballot in the first half of 2017.

Assuming that this pre-final draft will be substantially the same as the final approved standard, the standard will be far lengthier, of greater complexity, and hopefully more exact in wording than the 2003 version. Whereas the 2003 version has nine pages of "meat" (text, excepting introductory front material and annexes), the present draft of the revised standard now has nearly sixty pages. This is necessary due to the ever increasing complexity of defining active distribution systems with potentially many sources of generation, and coordinating DER with the reliability and security needs of the bulk power system.

There are many changes under final consideration in the new standard. These represent the balance of divergent interests of the many parties involved, including utilities, bulk system operators, developers, DER vendors, and state regulators. Some of the most significant changes are:

- Elimination of the 10 MVA cap on the standard's applicability; it now covers any generation connected to distribution systems.

Review of the new IEEE 1547 by co-op engineers and participation in balloting will help to ensure that the needs of the rural cooperative segment of the power industry are appropriately addressed.

- Requirements for DER to have leading and lagging reactive power capability, and a number of different reactive control functionalities to be employed with agreement by the utility.
- Mandatory voltage and frequency disturbance ride-through capability.
- Primary frequency response (governor) functionality to allow DER to help mitigate grid-wide frequency disturbances.
- Clarification for the need to coordinate DER with feeder reclosing, so that out-of-phase reclosing does not occur.
- More refined and updated power quality requirements that address the power-electronic technology being used today in the majority of DER applications.
- Interoperability requirements that will allow DER to be better integrated into smart, automated distribution systems.
- Testing that helps characterize short-circuit current characteristics of inverters.

The next three articles in NRECA's *TechSurveillance* series will describe these technical requirement changes; one dedicated to the reactive power and voltage regulation topic, the next to fault and disturbance-related performance, and the last which will tackle the separate subjects of power quality and interoperability.

IMPACT ON COOPERATIVES

DER will continue to grow in penetration and play an increasing role in distribution systems everywhere. As the national DER standard, IEEE 1547 will directly affect the capabilities and flexibility of DER equipment, and will define how these sources will be integrated into the distribution systems. This can have an impact on the way co-op distribution systems need to be designed and operated well into the future.

With the increase of DER across the nation's power grid, they will have an effect on bulk system security and reliability. DER connected now will be around for a long time. A retrofit program to make DER compatible with grid needs long after it is installed would be an administrative and legal nightmare.

Overall, the characteristics of co-op feeders tend to differ from typical IOU-owned feeders, which by and large serve urban and suburban service areas. Although the time for participation in draft development is coming to a close, there is an opportunity for more co-op engineers to participate in the balloting process. The IEEE-SA standards balloting process, and the procedure to join the ballot pool is described below. Review of the new IEEE 1547 by co-op engineers and participation in balloting will help to ensure that the needs of the rural cooperative segment of the power industry are appropriately addressed. ■

BALLOTING PROCESS FOR IEEE 1547

How to become a member of the balloting pool for IEEE Standards

Ballot pools for IEEE standards are distinct from the working groups that develop the standards drafts. Joining a ballot pool for a particular standard is totally separate from joining the working group.

To participate in IEEE standard balloting, you first need to join the IEEE Standards Association as a part of your IEEE membership. Currently, this costs an additional $53 in addition to your

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BALLOTING PROCESS FOR IEEE 1547 (CONT.)

IEEE and any IEEE technical society memberships that you have. This gives you the ability to vote on an unlimited number of standards that enter the balloting process. Note that there is a process to pay a per-ballot fee without joining IEEE or the Standards Association, but that is not applicable for most of us.

When you join the Standards Association, you should develop an "Activity Profile" within the myProject™ web site (**https://development.standards.ieee.org**). This allows you to select sponsor committees, working groups, and projects in which you are interested. You will receive invitations to enroll in the ballot pools for the standards that these groups develop. For example, if you search on "distribution," you will get a number of committees, working groups, and projects that have "distribution" in their name. By selecting the sponsor level, in this case, "PE/T&D (PES Transmission and Distribution Committee), you will receive notices of all standards coming to ballot that are sponsored by this entity. If you are specifically interested in other committees, working groups, or projects, you should check those as well.

For IEEE 1547 specifically: you need to add SCC21 (Standards Coordinating Committee 21 – Fuel Cells, Photovoltaics, Dispersed Generation, and Energy Storage) to your profile.

Any IEEE-SA member can join any ballot group during the invitation period. It is up to the individual to determine that they are technically qualified to review, comment, and vote on the standard being balloted. When you join the ballot group, you must declare an interest category (e.g. producers, users). No interest category can comprise over one-third of the balloting group. The goal is to have representation from all interested parties, but to avoid an overwhelming influence by any one of those parties. The sponsor entity can reject requests for ballot pool membership as necessary to obtain this balance. A proposed standard will pass if at least 75 percent of all ballots from a balloting group are returned, and if 75 percent of these bear a "yes" vote. For example, if ballot returns of 30 percent are abstentions, the ballot fails.

Balloters vote to approve, disapprove, or abstain. They can also approve or disapprove with comment. Balloters that disapprove are highly encouraged to provide comments of changes in the standard that will allow them to change their vote from disapprove to approve. The ballot resolution group responds to all comments whether submitted by a voter that approves or disapproves the standard. Comments are often straightforward editorial or technical changes to the standard. The standard, with changes based on the comments received, are recirculated to the balloting group. The balloting group can then make comments on the changes made, and also has the opportunity to change their vote based on revised standard. The hope is that the changes will persuade balloters that previously disapproved to change to approving the standard, but there is a possibility that some that originally approved of the standard will change their ballot to "disapprove." The process can require several rounds of balloting, revision, and recirculation. In the end, the objective is to reach a consensus that is widely accepted across the industry.

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About the Author

Reigh Walling is a utility and renewable energy industry consultant, focusing his practice on the technical issues related to DER interconnections and renewable energy integration, as well as a variety of transmission-related areas. He has long been heavily involved in standards related to interconnection of DER and transmission-scale renewable energy plants, including participation in the inner writing group of the original IEEE 1547, several of the IEEE 1547.x companion standards, NERC PRC-024, and the NERC Integration of Variable Generation Task Force, and as well as a co-facilitator in the current IEEE 1547 revision working group. Prior to establishing Walling Energy Systems Consulting in 2012, he was a key member of GE's Energy Consulting group for 32 years. While at GE, he was the program manager for the Distribution Systems Testing, Application, and Research utility consortium, of which NRECA is a long-standing member.

Questions or Comments

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- Business and Technology Strategies **feedback line**.
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